Forty-ninth Annual Convention
Hotel Commodore, New York City
September 24-27, 1940

Volume 54 | June, 1940 | $4.00 a Year
Number 2 | Pages 149-274 | $1.25 a Number

JOURNAL

OF THE

New England Water Works Association

ISSUED QUARTERLY

Published by
THE NEW ENGLAND WATER WORKS ASSOCIATION
613 Statler Building, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879
Copyright, 1940, by the New England Water Works Association

OFFICERS
OF THE
New England Water Works Association
1939-1940

PRESIDENT

PERCY A. SHAW, Superintendent and Engineer, Manchester, N. H.
(Term expires September, 1940)

VICE-PRESIDENTS

LELAND G. CARLTON, Water Registrar, Springfield, Mass.
(Term expires September, 1940)

FRANCIS H. KINGSBURY, Massachusetts State Department of Health, Boston, Mass.
(Term expires September, 1941)

DIRECTORS

HAROLD L. BRIGHAM, Superintendent, Marlborough Water and Sewage Commission, Marlborough, Mass.
(Term expires September, 1940)

HORACE L. CLARK, Superintendent, Sanford Water District, Sanford, Me.
(Term expires September, 1941)

KARL R. KENNISON, Chief Engineer, Metropolitan District Water Supply Commission, Boston, Mass.
(Term expires September, 1942)

PAST PRESIDENTS
(Members of the Executive Committee)

WARREN J. SCOTT, Director, Bureau of Sanitary Engineering, Connecticut State Department of Health, Hartford, Conn.

GEORGE A. SAMPSON of Weston & Sampson, Consulting Engineers, Boston, Mass.

SECRETARY

FRANK J. GIFFORD, Dedham, Mass.

TREASURER

ABEL REYNOLDS, Treasurer, New England Water, Light & Power Associates, Providence, R. I.

EDITOR

GORDON M. FAIR, 112 Pierce Hall, Harvard University, Cambridge, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 800 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Life Member shall be a member whose service to the Association entitles him to special recognition by the Association.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

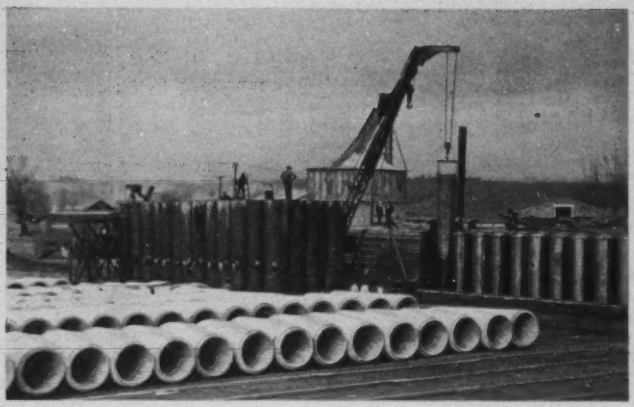
An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation

The initiation fees and annual dues are as follows:

	Initiation Fees		*Annual Dues*
Members	$ 3.00	Members	$ 6.00
Juniors	1.00	Juniors	3.00
Associates	10.00	Associates	20.00
Corporate Members	10.00	Corporate Members	10.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.



SKILLED SUPERVISION
FROM START TO FINISH

The production of Lock Joint Reinforced Concrete Pressure Pipe Lines from the fabrication of the pipe in local manufacturing plants to its final installation is a skilled operation, developed to a high degree of perfection.

To supervise the production and installation of these pipe lines is the responsibility of highly skilled men, some of whom have been making Lock Joint Pipe for 20 years and more. Hundreds of miles of this pipe, in sizes from 20″ to 150″, now in service, are proof of their ability.

Highly efficient methods have been developed and constantly improved during the past 35 years so that no matter in what locality the pipe is manufactured the results will be the same—safe, indestructible, long-life pipe lines.

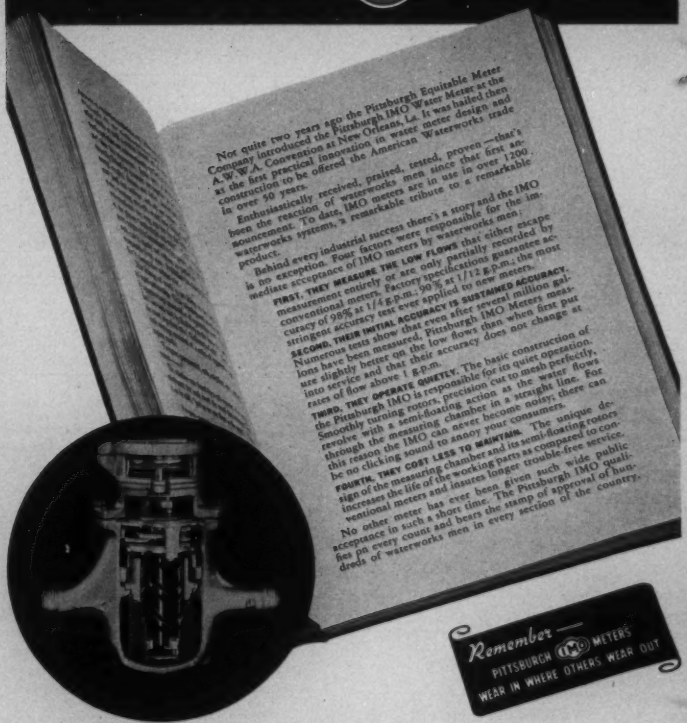
PRESSURE ● SUBAQUEOUS ● SEWER ● CULVERT

LOCK JOINT *Reinforced Concrete* PRESSURE PIPE

LOCK JOINT PIPE CO. Established 1905 AMPERE N. J.

A Page from the Success Story of

PITTSBURGH IMO METERS


Not quite two years ago the Pittsburgh Equitable Meter Company introduced the Pittsburgh IMO Water Meter at the A.W.W.A. Convention at New Orleans, La. It was hailed then as the first practical innovation in water meter design and construction to be offered the American Waterworks trade in over 50 years.
Enthusiastically received, praised, tested, proven—that's been the reaction of waterworks men since that first announcement. To date, IMO meters are in use in over 1200 waterworks systems, a remarkable tribute to a remarkable product.
Behind every industrial success there's a story and the IMO is no exception. Four factors were responsible for the immediate acceptance of IMO meters by waterworks men:
FIRST, THEY MEASURE THE LOW FLOWS that escape conventional meters, or are only partially recorded by them. Factory specifications guarantee accuracy of 98% at 1/4 g.p.m.; 90% at 1/12 g.p.m.; the most stringent accuracy ever applied to new meters.
SECOND, THEIR INITIAL ACCURACY IS SUSTAINED ACCURACY. Numerous tests show that even after several million gallons have been measured, the Pittsburgh IMO Meters measure slightly better on the low flows than when first put into service and that their accuracy does not change at rates of flow above 1 g.p.m.
THIRD, THEY OPERATE QUIETLY. The basic construction of the Pittsburgh IMO is responsible for its quiet operation. Smoothly turning rotors, precision cut to mesh perfectly, revolve with a semi-floating action as the water flows through the measuring chamber in a straight line. For this reason the IMO can never become noisy; there can be no clicking sound to annoy consumers.
FOURTH, THEY COST LESS TO MAINTAIN. The unique design of the measuring chamber and its semi-floating rotors increases the life of the working parts as compared to conventional meters and insures longer trouble-free service.
No other meter has ever been given such wide, public acceptance in such a short time. The Pittsburgh IMO qualifies on every count and bears the stamp of approval of hundreds of waterworks men in every section of the country.

Remember — PITTSBURGH IMO METERS WEAR IN WHERE OTHERS WEAR OUT

PITTSBURGH EQUITABLE METER COMPANY

MERCO NORDSTROM VALVE CO.

NEW YORK · BUFFALO · PHILADELPHIA · KANSAS CITY · TULSA · LOS ANGELES · *Main Offices* - PITTSBURGH, PA. · DES MOINES · CHICAGO · COLUMBIA · MEMPHIS · OAKLAND · HOUSTON

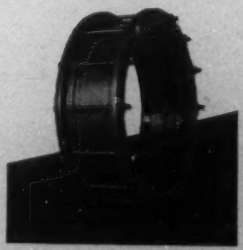
MAKE YOUR PLANS TO ATTEND THE 60TH ANNUAL MEETING OF THE AMERICAN WATER WORKS ASSOCIATION, KANSAS CITY, MO. THE WEEK OF APRIL 21, 1940.

Thousands of IMO Meters Are Now in Service —
Over ~~1100~~ 1200 Water Works Systems Have Adopted Them

1. THROUGH Colorado's mighty mountains. 2. WATERING a golf course for National Steel Corp. at Weirton, W. Va. 3. ROUNDING a curve in Fort Wayne's great water artery. 4. THE "UNEMPLOYED" built straight and true from reservoir to the heart of Auburn, N. Y. 5. DEFLECTING sharply at the crossroads, Bradford, Pa. 6. CARRYING water through Panther Valley to the collieries at Tamaqau, Pa. 7. LORAIN (Ohio) took every precaution to insure long life for this water line.

North, South, East, West, modern water lines are Dresser Coupled. THIS is the one jointing method that combines simplicity, speed, flexibility, strength, economy, and *absolute, permanent* tightness — proved conclusively over a period of fifty years.

Dresser Couplings are available for all kinds and sizes of plain-end steel and cast iron pipe, in sizes from 3-8 in. I.D. to 24 in. O.D. and larger.



DRESSER MFG. CO. - BRADFORD, PA.

IN CANADA: Dresser Mfg. Company, Ltd., 60 Front Street, West, Toronto, Ontario

Table of Contents

PAGE

The Useful Life of Iron and Steel Standpipes. By Charles W. Sherman 149

Hydraulic Investigation of a Small Water Works System and Effects of Main Cleaning. By Richard H. Ellis 155

Results of Better Maintenance and Sizing of Water Meters. By H. W. Griswold 164

Cross-Connections and the Plumbing Testing Laboratory in the New Bedford Vocational School. By E. J. Sullivan 179

Lessons from Floods and Hurricane at Ware, Mass. By George F. Merrill 186

Explosives—Types and Uses. By C. H. Blocher 191

Real Estate Acquisitions for Metropolitan Boston's Water Supply in the Swift River and Ware River Watersheds. By James A. Christenson 194

Pictures and Public Relations at Westfield, Mass. By Harry H. Angell 256

Proceedings:

February Meeting 258

March Meeting 258

April Meeting 259

May Meeting 259

Progress Report of the Committee on Quality Tolerances of Water for Industrial Uses 261

New England Water Works Association
ORGANIZED 1882

Vol. LIV June, 1940 No. 2

This Association, as a body, is not responsible for the statements or opinions of any of its members

THE USEFUL LIFE OF IRON AND STEEL STANDPIPES

BY CHARLES W. SHERMAN*

[*Read February 15, 1940.*]

In this paper an attempt has been made to present definite information about a considerable number of standpipes, showing the actual service life of those which have been abandoned because of failure, deterioration, or inadequacy, and the actual present age of those which are still (1939) in use, but which have been in service so many years that they are probably nearing the end of their useful life.

Standpipes which had failed because of freak design, the use of improper materials, or for similar reasons are not taken into consideration. Descriptions of 45 such cases may be found in a series of articles upon "Standpipe Accidents and Failures" by W. D. Pence, in *Engineering News,* 1894 and 1895, and later reprinted in book form.

The "Manual of American Water Works," 1897 Edition, prepared by M. N. Baker and published by *Engineering News,* was utilized to obtain information about standpipes existing at that time, and which would, therefore, be at least 42 years old if still in service in 1939.

In general, the Manual showed the date of construction, the diameter and height, and whether the structure was of iron or steel. The localities in New England and New York where standpipes existed were listed, and letters were sent to water works men in or near those places asking whether the standpipes were still in use, and if not when they were removed; and also for definite information relating to dates of construction, dimensions, and material. Similar information relating to any later structures which were at least 35 years old was also requested.

As was to be expected, no replies came from many towns; but a large number of superintendents did reply, some of them at considerable length. I am grateful to all those who supplied information, without which this compilation could not have been made. Data from

*Consulting Engineer, Boston, Mass.

111 standpipes were obtained and are represented in the following tabulation and summary.

SERVICE LIFE OR PRESENT AGE OF STANDPIPES IN NEW ENGLAND AND NEW YORK

Place	Dimensions—ft. Diameter	Height	Material	Year of Construction	Abandonment	Service Life	Age in 1939
Maine							
Augusta	35	45	Steel	1901	*	—	38
Bangor	75	50	Steel	1899	*	—	40
Bath	34	74	Iron	1887	1930	43	—
Belfast	30	45	Iron	1888	*	—	51
Boothbay Hbr.	45	30	—	1894	*	—	45
Brewer	30	100	Steel	1904	*	—	35
Brunswick	40	70	Iron	1886	1939	53	—
Caribou	29	30	Steel	1888	*	—	51
Eastport	30	60	Steel	1888	*	—	51
Ellsworth	25	80	Steel	1889	*	—	50
Farmington	40	25	Iron	1892	*	—	47
Freeport	35	60	—	1891	*	—	48
Gorham	35	50	Steel	1898	*	—	41
Kennebunk	30	111	—	1896	*	—	43
Mechanic Falls	30	60	Steel	1885	*	—	54
North Berwick	25	50	Steel	1897	*	—	42
Old Town	30	100	Steel	1902	*	—	37
Orono	30	75	Steel	1904	*	—	35
Pittsfield	25	60	Iron	1895	*	—	44
Portland	40	75	Steel	1904	*	—	35
Portland	36.5	77	Iron	1892	*	—	47
Portland	35	50	Steel	1898	*	—	41
Sanford	40	80	Steel	1897	1904	7	—
Skowhegan	25	75	Steel	1887	*	—	52
Southwest Hbr.	28	25	Steel	1895	*	—	44
Yarmouth	30	50	Steel	1896	*	—	43
New Hampshire							
Derry	30	35	Iron	1890	*	—	49
Exeter	25	60	Steel	1886	*	—	53
Hudson	12	60	—	1891	1939	48	—
Portsmouth	30	100	—	1892	*	—	47
Portsmouth	85	20	—	1898	*	—	41
Raymond	15	90	—	1894	*	—	45
Somersworth	40	95.5	Steel	1894	*	—	45
Rhode Island							
Bristol	40	35	Iron	1882	1908	26	—

*Still in use.

SERVICE LIFE OR PRESENT AGE OF STANDPIPES IN NEW ENGLAND AND NEW YORK (*continued*)

Place	Dimensions—ft. Diameter	Height	Material	Year of Construction	Abandonment	Service Life	Age in 1939
East Greenwich	26	40	Iron	1886	1907	21	—
Jamestown	30	50	Steel	1889	1915	26	—
Pascoag	20	100	Iron	1902	*	—	37
Wakefield	30	70	Iron	1888	*	—	51
Westerly	30	70	Iron	1886	*	—	53
Woonsocket	50	30	Iron	1884	*	—	55
Woonsocket	50	35	Iron	1889	*	—	50
Woonsocket	76	30	Steel	1891	*	—	48
Connecticut							
Litchfield	30	42	Iron	1890	*	—	49
Putnam	30	45	Iron	1886	1930	44	—
Suffield	25	80	Steel	1896	*	—	43
Thompsonville	40	40	—	1885	1915	30	—
Windsor Locks	20	100	Iron	1885	1928	43	—
Massachusetts							
Abington	25	100	Iron	1886	*	—	53
Arlington	40	60	Iron	1895	1922	27	—
Attleboro	30	125	Iron	1890	1905	15	—
Avon	20	90	Iron	1889	*	—	50
Boston							
Roxbury	5	80	Iron	1870	1887	17	—
Breed's Ld.	24	40	Iron	1888	1931	43	—
W. Roxbury	24	40	Iron	1886	1915	29	—
Braintree	30	100	Iron	1887	*	—	52
Bridgewater	25	75	—	1887	*	—	52
Brockton	62	59	Iron	1892	1912	20	—
Brockton	75	35	Steel	1903	*	—	36
Brookline	50	30	Iron	1889	1939	50	—
Canton	35	65	Iron	1889	1925	36	—
Dedham	30	103	Iron	1881	*	—	58
Dedham	42	51	Iron	1889	*	—	50
Dedham	20	25	Steel	1901	*	—	38
Dracut	25	50	—	1892	1935	43	—
Fall River	73	37	Iron	1886	1938	52	—
Fall River	65	56	Iron	1892	1938	46	—
Fall River	65	55	Iron	1897	*	—	42
Foxboro	20	120	Iron	1891	*	—	48
Framingham	40	80	Steel	1898	*	—	41
Franklin	30	80	Iron	1888	*	—	51

*Still in use.

SERVICE LIFE OR PRESENT AGE OF STANDPIPES IN NEW ENGLAND AND NEW YORK (*continued*)

Place	Dimensions—ft. Diameter	Height	Material	Year of Construction	Year of Abandonment	Service Life	Age in 1939
Grafton	25	30	Iron	1887	*	—	52
Haverhill	30	40	Iron	1879	1904	25	—
Haverhill	40	60	Steel	1887	1898	11	—
Holliston	30	60	Iron	1891	*	—	48
Hyde Park	50	35	Iron	1885	1912	27	—
Manchester	35	75	—	1892	1919	27	—
Marblehead	30	100	Iron	1889	*	—	50
Middleboro	20	103	Iron	1885	1915	30	—
Millis	20	80	Iron	1891	1935	44	—
Needham	25	85	Iron	1891	*	—	48
Newburyport	40	35	Iron	1881	1900	19	—
North Easton	20	103	Iron	1888	*	—	51
Oak Bluffs	20	70	—	1890	*	—	49
Provincetown	28	100	Iron	1893	1931	38	—
Quincy	35	60	Iron	1883	1930	47	—
Randolph	30	125	Iron	1887	*	—	52
Reading	30	100	Iron	1890	*	—	49
Rockport	30	60	Iron	1894	*	—	45
Scituate	25	75	—	1900	*	—	39
Somerville	30	100	Iron	1889	1899	10	—
Spencer	40	39	Steel	1899	*	—	40
Stoughton	30	60	Iron	1886	1926	40	—
Swampscott	26	110	—	1885	1899	14	—
Vineyard Haven	20	50	—	1887	1924	37	—
Wakefield	40	62	Iron	1883	*	—	56
Watertown	40	40	Iron	1884	1898	14	—
Webster	30	100	Iron	1894	1939	45	—
Weymouth	40	75	Iron	1889	*	—	54
Winchester	40	76	Steel	1898	*	—	41
New York							
Baldwinsville	20	50	Iron	1890	*	—	49
Brooklyn	16	75	Iron	1893	1928	35	—
Carthage	20	75	Steel	1893	*	—	46
Cortland	40	40	Iron	1884	1929	45	—
Fulton	20	80	Iron	1885	1912	27	—
Phoenix	20	80	Iron	1888	*	—	51
Rockville Cen.	20	100	Iron	1896	1928	32	—
Schenectady	32	100	Steel	1896	1921	25	—
Seneca Falls	30	80	Steel	1887	1889	2	—

*Still in use.

SERVICE LIFE OR PRESENT AGE OF STANDPIPES IN NEW ENGLAND AND NEW YORK (*continued*)

Place	Dimensions—ft. Diameter	Height	Material	Year of Construction	Year of Abandonment	Service Life	Age in 1939
Seneca Falls	30	95	Steel	1890	*	—	49
Waterford	30	54	Steel	1885	1927	42	—
Waterford	25	85	Steel	1898	1927	29	—

*Still in use.

SUMMARY

Maine:

Standpipes abandoned, 3; average life, 34 years; range, 7 to 53 years.

Standpipes still in use after 35 years or more, 23; average age, 44 years; maximum age, 54 years.

Total reported, 26; average life* of all, 49 years.

New Hampshire:

Standpipes, abandoned, 1; life, 48 years.

Standpipes still in use after 35 years or more, 6; average age, 47 years; maximum age, 53 years.

Total reported, 7; average life* of all, 53 years.

Rhode Island:

Standpipes abandoned, 3; average life, 24 years; range, 21 to 26 years.

Standpipes still in use after 35 years or more, 6; average age, 49 years; maximum age, 55 years.

Total reported, 9; average life* of all, 46 years.

Connecticut:

Standpipes abandoned, 3; average life, 39 years; range, 30 to 43 years.

Standpipes still in use after 35 years or more, 2; average age, 46 years; maximum age, 49 years.

Total reported, 5; average life* of all, 45 years.

Massachusetts:

Standpipes abandoned, 26; average life, 31 years; range, 10 to 56 years.

Standpipes still in use after 35 years or more, 26; average age, 48 years; maximum age, 58 years.

Total reported, 52; average life* of all, 43 years.

New York:

Standpipes abandoned, 8; average life, 30 years; range, 2 to 45 years.

Standpipes still in use after 35 years or more, 4; average age, 49 years; maximum age, 51 years.

Total reported, 12; average life* of all, 38 years.

Six States:

Standpipes abandoned, 44; average life, 32 years; range, 2 years to 56 years.

Standpipes still in use after 35 years or more, 67; average age, 47 years; maximum age, 58 years.

Total reported, 111; average life* of all, 45 years.

In summarizing the results, it has been assumed that the standpipes still in use will have a further life of as much as 15 years in some cases; and the actual average age has been increased by 7 years to obtain their probable average life. The average probable service life of the 67 standpipes still in use would then be 54 years.

By contrast, we find the average life of those which have been abandoned is 32 years. Some of those had become unsafe, but a considerable number were removed because they were superseded by other structures, or had become inadequate to meet increasing needs, or were at too low elevations for satisfactory service. The average life of all standpipes abandoned was 32 years.

The average probable life of all the 111 standpipes is 45 years.

*Assuming an average additional life of 7 years for all standpipes 35 years or more old and still in use.

HYDRAULIC INVESTIGATION OF A SMALL WATER WORKS SYSTEM AND EFFECTS OF MAIN CLEANING

BY RICHARD H. ELLIS*

[*Read March 21, 1940.*]

The purpose of presenting this paper is not to set forth any new technical matter but rather again to direct the attention of the water works operators to the value of being acquainted with the hydraulics of their distribution systems. By the application of some of the simplest of the hydraulic theories that have been explained to this Association by Prof. Geo. E. Russell in his pre-meeting talks, it is possible to conduct a sufficiently thorough examination of the carrying capacity of trunk and distribution mains to indicate their ability to deliver to any part of a water works system the amount of water required for domestic and fire service. It is further possible by the application of these same principles to predict with reasonable certainty the effect of laying new mains or of reconditioning existing pipe lines.

To illustrate the simplicity of such an investigation, and the accuracy of the prediction possible, I will cite as an example an investigation recently conducted in Millers Falls, in the western part of Massachusetts.

Millers Falls is a Postal Sub-Division embracing parts of the towns of Erving and Montague, which towns are separated by the Millers River. See Fig. 1. The district referred to as Millers Falls covers an area of about 4 sq. miles and has a population of about 1800. The two principal industries within the district, the Millers Falls Paper Co. and The Millers Falls Co., a tool manufacturing establishment, are located on the river in the eastern and western portions of the district, respectively. The primary supply of water for the fire protective systems at these plants is from public mains, while each plant provides its own secondary supply from fire pumps which draw suction from a canal or from the Millers River.

The Millers Falls Fire and Water District was formed to provide public water for domestic and fire protection purposes for those sec-

*Engineer, Inspection Department, Associated Factory Mutual Fire Insurance Company, Boston, Mass.

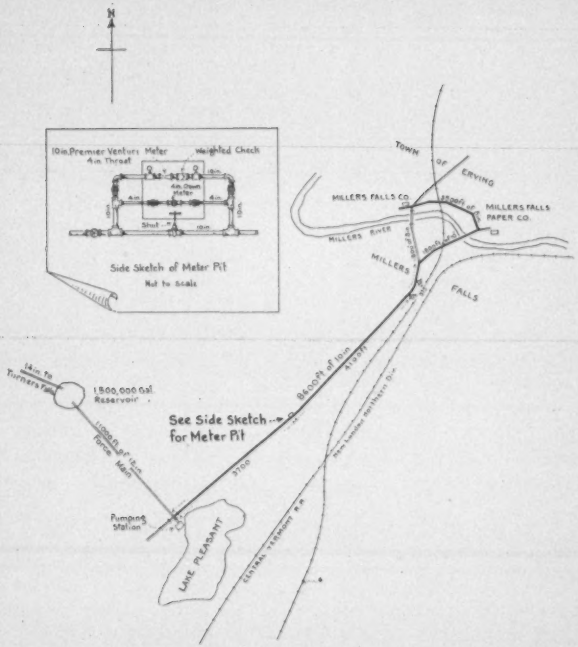


FIG. 1.—MILLERS FALLS FIRE AND WATER DISTRICT.

tions of the two towns that are included within the district. The water works system is supplied from the Turners Falls Fire and Water District's system through a 10-in. connection to the 11,400-ft. long 12-in. force main through which water is supplied to the Turners Falls reservoir. The Millers Falls connection is located about 400 ft. north of the Pumping Station.

Water is pumped directly from Lake Pleasant to both the Millers Falls and Turners Falls systems and overflows to the 1.5-m.g. Turners Falls reservoir. A 2-m.g.d. Blake duplex pump was ordinarily operated about 10 to 12 hours per day against a head of 150 lb. per sq. in. to supply the demand of both communities, while a 1.2-m.g.d. steam duplex unit was held in reserve.

The average daily consumption of water for both these systems is about 800,000 gal. According to meter registration, an average of 44,500 g.p.d. of water was supplied to Millers Falls in 1938, making a per capita consumption for the District of but 24.7 g.p.d. With all services in this district metered and with this low per capita daily consumption, it is reasonable to assume that there was no undue leakage.

Water supplied to the Millers Falls system is recorded on a 4-in. oscillating piston type meter, on a bypass, and on a 10 by 4 in. Venturi type meter with weighted check, on a second bypass, located about 3700 ft. from the Pumping Station. This arrangement results in small flows being registered only on the smaller meter, while with an increased head loss due to larger flows water would be recorded on both meters. A gate in the 10-in. main is kept shut so that water ordinarily passes through one or both of these bypass meters. In case of fire the main gate can be opened, thus eliminating the friction in the meters, although considerable delay might be expected in getting this gate open.

The trunk main supplying Millers Falls consists of approximately 11,000 ft. of 10-in. cast-iron pipe which extends through the business center of the eastern part of the district. Water is supplied to the northern part of the district through about 1800 ft. of 8-in. pipe which is fed from a connection with the 10-in. pipe in the center of the business district and through some 3500 ft. of 8-in. pipe, which forms a loop between the end of the 10-in. pipe and the 8-in. pipe which crosses Millers River to the northern part of the district.

The quantity of water available from the public system for fire protection at the industrial properties was known to have diminished rapidly in the last few years, and recommendations for improvement had been made to the industries. This deficiency was pointedly brought to the attention of the town when a lack of water was experienced during two fires in residential properties. Because of the deficiency in water supply, a committee was formed to study means of providing sufficient water for fire protection purposes. This Committee solicited the advice of the Inspection Department of the Associated Factory Mutual Fire Ins. Cos. as that organization was vitally interested in the protection of the industrial properties.

To determine the quantity of water available for fire protection, capacity tests were run in the business and residential sections of the

district by Pitot measurement of the flow from flowing hydrants and noting the residual pressures. These tests indicated a definite deficiency, there being available in the business district but 600 g.p.m. at 20 lb. per sq. in. while the quantities available in the residential district, fed by 4- and 6-in. mains were negligible.

In order to ascertain whether the deficiency was due to a local obstruction or to a general condition of the trunk mains, normal pressures were noted at all hydrants and at several house taps along the 3,500 ft. of 8-in. and 11,000 ft. of 10.-in. cast-iron main which extends to the east and thence through the north to the west side of the district. A test was then run by drawing 420 g.p.m. (figured from Pitot readings) from a hydrant in the yard of the Millers Falls Co. and noting the residual pressures at all points where normal pressures had previously been read. Meter readings taken prior to, during and directly following the test indicated that the average domestic consumption within the District at that time was 20 g.p.m. in the pipe line under consideration, resulting in the originally noted normal pressures being practically the same as static pressures.

From these data a hydraulic gradient (See Fig. 2) was plotted by subtracting the static pressure noted at any point from the pump pressure and adding thereto the residual pressure noted at the same location. Due to the flow test being made with the pumps oper-

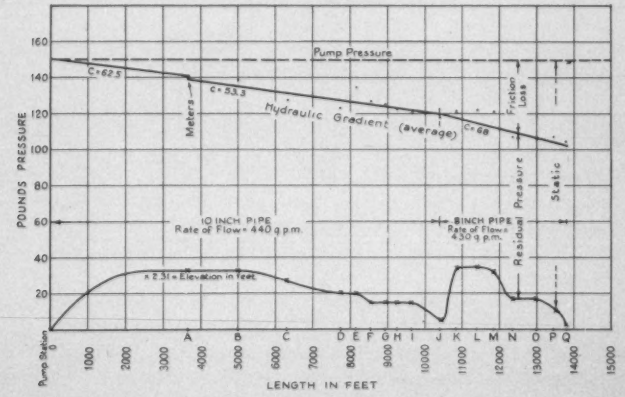

Pump Pressure
C=62.5
C=53.3
Meters
Hydraulic Gradient (average)
C=68
Friction Loss
Residual Pressure
Static
10 INCH PIPE
Rate of Flow = 440 g.p.m.
8 INCH PIPE
Rate of Flow = 430 g.p.m.
x 2.31 = Elevation in Feet
POUNDS PRESSURE
LENGTH IN FEET
Pump Station
A B C D E F G H I J K L M N O P Q
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000

FIG. 2—HYDRAULIC GRADIENTS OF 10-IN. AND 8-IN. CAST-IRON MAINS.

ating there was considerable pressure fluctuation in the mains under flow conditions. The hydraulic gradient plotted was of necessity an average of the points plotted for observed conditions. The slope of the average gradient on the 10-in. pipe between the Pumping Station and the Meter House and between the Meter House and the end of the 10-in. main will be found by reference to the Williams and Hazen tables to have coefficients of about 62.5 and 53.3, respectively, while the coefficient of the 8-in. pipe equals 68 (figures by slide rule).

The friction loss curve—the hydraulic gradient plotted in reverse—is shown on Fig. 3, on which has also been plotted the ex-

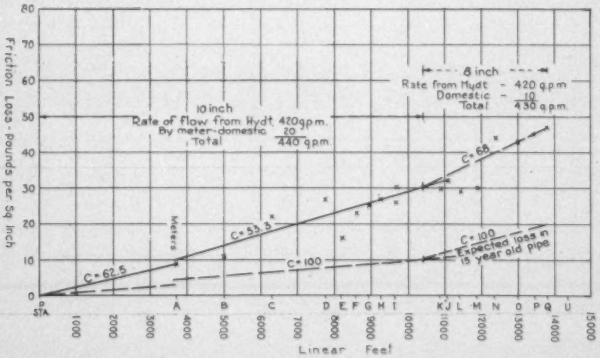


FIG. 3—OBSERVED FRICTION LOSS OF 10-IN. AND 8-IN. CAST-IRON MAINS.

pected friction in a main having a coefficient of C = 100. The difference between these two curves is, at the given rate of flow, the extra friction developed due to the age and condition of the pipe line and is not greatly in excess of what would be expected in a pipe of this age (over 40 years old).

Observations of pressures at the pumping station showed that the pressure was increased from a static of 82 lb. per sq. in. to 150 lb. per sq. in. when the pumps were operating at a rate of 1325 g.p.m. This is indicative of a Williams & Hazens coefficient of about 67 in the 11,400 ft. of 12-in. pipe between Pumping Station and the Turners Falls reservoir. The head against which the pumps operated had increased about 40 lb. per sq. in. in a 25-year period. Due to the Mil-

lers Falls system being supplied from the Turners Falls force main within a short distance of the pumping station, the increased pressure caused by the friction developed in delivering water to the reservoir was transmitted to the Millers Falls system, and this increase in pressure offset, to a large degree, the loss in effective carrying capacity while the pumps were in operation.

To provide an adequate quantity of water for fire protection, it was evident, since there were no local obstructions in the trunk main, that one of the following three remedies should be adopted.

1. An additional trunk main should be constructed to augment the flow available through the existing mains.

2. Elevated storage should be provided near the business and industrial districts.

3. The existing mains should be cleaned.

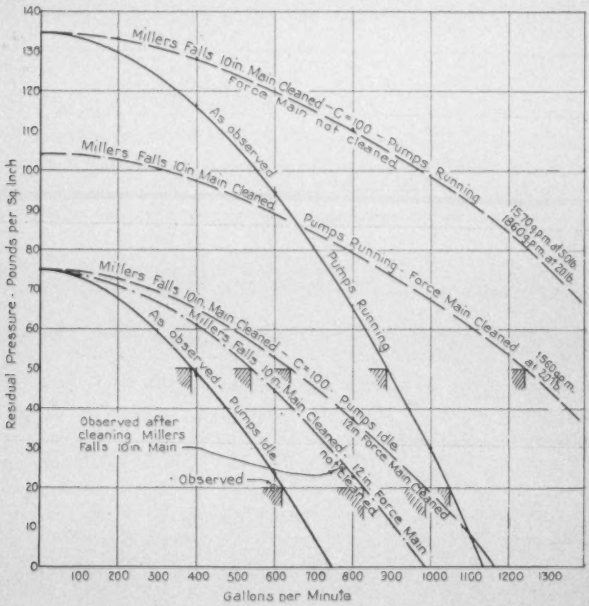

Residual Pressure - Pounds per Sq. Inch
Gallons per Minute
Millers Falls 10in. Main Cleaned - C=100 - Pumps Running
Force Main not cleaned
As observed
Millers Falls 10in. Main Cleaned
Pumps Running
1570 g.p.m. at 50lb.
1640 g.p.m. at 20lb.
Pumps Running - Force Main Cleaned
Millers Falls 10in. Main Cleaned - C=100
1560 g.p.m. at 20lb.
Millers Falls 10in. Main Cleaned
As observed - Pumps Idle
Pumps Idle
Observed after cleaning Millers Falls 10in. Main
Observed
12 in. Force Main Cleaned
12 in. Force Main not cleaned

FIG. 4—WATER AVAILABLE AT BRIDGE AND MAIN STREETS, MILLERS FALLS.

As the investment necessary for the accomplishment of the first two suggestions was greater than the community desired to make, studies were undertaken to determine the yield that would be expected if the existing mains were cleaned.

Utilizing the coefficients developed from the observed pressure losses under flow conditions, supply curves (Fig. 4) were prepared (by plotting various rates of flow against residual pressures) to show the quantities available at the time of the investigation and what would be expected if the mains were cleaned. Because of the wide variation of pressures in the Millers Falls system between pumping and gravity flow conditions, these supply curves were plotted to show under each condition:

1. Present yield.
2. Expected yield with Millers Falls trunk main cleaned.
3. Expected yield with both Millers Falls mains and the force main cleaned.

As will be noted from the curves plotted to show observed and expected conditions within the business district, there was available for direct hose streams at 50 lb. per sq. in. pressure about 380 g.p.m. and for fire department pumper supply but 620 g.p.m. at 20 lb. per sq. in. when drawing from the reservoir. Under pumping conditions these quantities were calculated to be 890 and 1,050 g.p.m. respectively.

Assuming a coefficient of $C = 100$ as being conservative for cleaned mains, it was predicted that after cleaning the Millers Falls mains and the force main the yield at the business section, under gravity conditions, would be increased to 640 g.p.m. at 50 lb. per sq. in. and 990 g.p.m. at 20 lb. per sq. in. pressure, and under pumping conditions to 1,570 g.p.m. at 50 lb. per sq. in. and 1,860 g.p.m. at 20 lb. per sq. in. pressure. Corresponding increases would be available throughout the length of the 10- and 8-in. mains.

It is interesting to note that while the study was being made primarily to increase the flow to Millers Falls, it showed that the cleaning of the force main as well as the Millers Falls mains actually would result in less water being available during periods when the pumps are operated than if the Millers Falls mains alone were cleaned. However, considerably more water would be available from the reservoir under gravity flow which result was most desired.

As a result of this investigation the Millers Falls Fire and Water

District started a main-cleaning program and during 1939 cleaned both the 10-in. and 8-in. mains on which the test herein described was conducted. After the pipe cleaning work was completed, but prior to the cleaning of the force main by the Turners Falls Fire and Water District, an opportunity presented itself to check the efficiency of the pipe-cleaning work. An open butt hydrant test run in the business section of the district gave results which confirmed the prediction as to the quantity that might be expected under that condition and indicated that with both force and trunk mains cleaned there would be at 50 lb. per sq. in. about 70%, and at 20 lb. per sq. in. about 45% more water than was available from these mains at the time of the original investigation.

The resulting improvement, in making available an increased quantity of water for fire protection purposes, while not the most satisfactory solution of the Millers Falls Fire & Water Districts difficulties, was readily and inexpensively accomplished. The ultimate provision of elevated storage near the center of the District would still further increase the adequacy and improve the reliability of this system.

Subsequent to the work in Millers Falls, the Turner Falls Fire and Water District undertook the cleaning of its force main with the result that the rate of pumping was increased from 1,325 g.p.m. to 1,500 g.p.m. while the head against which the pumps operate was reduced from 150 to 115 lb. per sq. in. It is understood that quantities as great as 1,700 g.p.m. have been pumped without increasing the head over 120 lb. per sq. in. This is indicative of a Williams & Hazen coefficient of between 115 and 122 and results in the ability to pump an increased quantity of water with the present pumping equipment, and in a reduction of about 29% in the cost of pumping water.

Investigation such as that here described can readily be conducted on any part of a distribution system by use of ordinary gages and a Pitot tube, and calculations can be worked out by use of fire flow and friction loss tables. The results of such tests, while not necessarily highly accurate, are sufficiently so to indicate the general conditions of the pipe lines and the maximum probable yield to be expected therefrom and are of great assistance in redesigning a distribution system.

The writer would urge water works operators to study the hydraulics of their distribution systems so that they may become thor-

oughly acquainted with the points of greatest deficiency therein and in order that logical plans may be developed for the required strengthening of their systems.

The writer desires to acknowledge the assistance rendered by D. E. Matthewson, Commissioner and Clerk of the Millers Falls Fire and Water District who coöperated in running the tests herein described and also to M. S. O'Leary, Secretary of the Turners Falls Water Commissioners who furnished the data relative to past and present pumping conditions.

RESULTS OF BETTER MAINTENANCE AND SIZING OF WATER METERS

BY H. W. GRISWOLD*

[*Read April 25, 1940.*]

In 1929, the writer presented a paper† before this Association titled "The Maintenance of Water Meters" in which were described the meter maintenance practice and costs then obtaining in the Water Department of the city of Hartford, and a discussion given of the various factors to be considered in setting up a program for improved maintenance of meters.

The five factors having the most effect on the cost and efficiency of small meter maintenance were summarized as:

1. Frequent inspection of meters in service to detect those not registering and those over-registering;
2. The prompt removal and replacement of "down" meters with a minimum of lost motion;
3. The testing of all meters at regular intervals;
4. The application of efficient factory methods to the repair shop and the testing bench;
5. Close control of records and stock.

In 1930, the four towns adjacent to the city, and the city of Hartford, were incorporated as The Metropolitan District of Hartford County, Conn., and the supply and distribution of water in this area and in the town of West Hartford were taken over by the Water Bureau of The Metropolitan District. Chas. A. Goodwin is Chairman of The Metropolitan District Commission, F. Spencer Goodwin is Chairman of the Water Bureau, and Caleb Mills Saville is Manager and Chief Engineer of the Water Bureau, in direct charge of all water department activities.

During the year after the formation of the District, the staff was occupied with problems of plant and personnel, incidental to the changeover from City to District control, but early in 1932 a start was made toward improving meter maintenance practice. Much thought and study have been given to this problem during the suc-

*Deputy Manager and Deputy Chief Engineer, Water Bureau, Metropolitan District, Hartford, Conn.

†This Journal 43 (1929), 273.

ceeding eight years, and it is the purpose of this paper to report in a brief way the methods found most satisfactory in the office, field, test room, and shop, and to attempt to evaluate the results obtained from improved meter maintenance and from better sizing of meters.

The number of each size of meter in service at the beginning of 1932 and the approximate income in percentage of total derived from each size are given in Table 1.

TABLE 1.—PERCENTAGE OF INCOME DERIVED FROM EACH SIZE OF METER IN 1932

Size of Meter	Number in Service	Per Cent of Income
Inches		
5/8	12,707	20
3/4	10,144	33
1	2,429	22
1¼ - 1½	457	10
2 and over	467	15
	26,204	100

Since the bulk of the meters in service is smaller than 1½ in., and also since they bring in about 70% of the total income from the sale of water, efforts toward improved practice were directed principally to the meters in these sizes, and the methods described apply particularly to them.

Office Methods. The objective here is to obtain adequate control and proper records with a minimum of paper work. Most of the progress made has been due to a carefully thought out four-copy work order form, so designed that the amount of copying is reduced to a minimum and the compilation of all essential data is facilitated. A perpetual inventory system in employed for meter stock, and a standard time sheet and pay roll system are used for labor. Meters due to come off for test are listed from meter readers' route books, and the rules of the Public Utilities Commission requiring that meters smaller than 1½ in. be changed after passing a given quantity of water, but not less often than once in five years, are strictly observed.

Field Methods. One man with half ton truck is the standard outfit for installing or changing small meters located inside buildings. Installations of new meters are facilitated by the requirement that a

pair of meter tailpieces with spacer nipple, furnished by the Bureau, be set by the plumber just inside the building, close to the shut-off valve and with a back valve immediately beyond it. This one-man crew also makes minor repairs on premises, such as broken glasses and small leaks in meter or connections, and runs over-all accuracy tests on the meter in place on special order, which is usually initiated by the customer because of high bill. A 1-cu. ft. test can, similar to those used for testing gasoline dispensing pumps, is used for these tests, and by making several runs at different rates of flow any gross inaccuracy of registration can be detected very readily.

Test Methods. Even if Public Utilities Commission rules did not require an "as found" test, it would be worthwhile making such a test, in order to have information on the behavior of repaired meters in service. The practice of testing small meters in strings of six to eight has been continued, but the rates of flow during test are controlled more closely by means of a Ford Testerate setter. Determination of quantity by weight has been abandoned in favor of direct volumetric measurement in special tanks having cone-shaped tops with two risers. During test, water enters the tank through one riser and, when the tank is nearly full, a float in the second riser is carried up and throws a mercoid switch, which causes an electrically operated valve on the outlet end of the test bench to close. This setup permits tests to be run without further attention after the flow is once started, and the automatic shutoff arrangement give a predetermined quantity in the tank within 1/10 per cent, regardless of rate of flow. Two tanks are used, one of 1-cu. ft. capacity, and the other of 10-cu. ft. capacity.

A second test bench and set of tanks were added last year, in order that tests at small flows might be run for a sufficient time to cause the 1-cu. ft. pointer to make a complete revolution. At ¼ g.p.m., it takes thirty minutes to run 1 cu. ft., but with automatic shut-off the operator can run the higher rate test flows on a second string of meters while the minimum test flow is running on the first string, so that there is no additional cost for making the more thorough test at minimum flow.

For testing 1½-in. and 2-in. meters, a home-designed bench holding three 1½-in. or two 2-in. disc meters, or one 2-in. compound meter, is used. Because of the greater range in test rates, both a Ford Testerate setter and an orifice plate, preceded by a pressure-

reducing valve, are used. Quantity is measured by weight, with arrangement for automatic shut-off when the scale beam starts to rise. By undersetting the weight on the scale beam by amounts determined by experience for each rate of flow, shut-off can be timed to give quantities in the tank which are exact to within about 1/3 per cent.

For each size of meter, the rates of flow which are used for testing, the quantity run for each test flow, and the required accuracy of registration are listed in Table 2.

TABLE 2.—STANDARD METER TESTS

Size of Meter Inches	Gallons per Minute	Cubic Feet	Time		Registration Required
			Minutes	Seconds	
5/8	5	1	1	30	98 — 102
	16	10	4	41	98 — 102
	0.8	1	9	22	98 — 102
	0.25	1	30	0	90
3/4	8	10	9	22	98 — 102
	25	10	3	0	98 — 102
	1.4	1	5	22	98 — 102
	0.5	1	15	0	90
1	13	10	5	46	98 — 102
	30	10	2	30	98 — 102
	2.2	1	3	25	98 — 102
	0.75	1	10	0	90

Any meter which registers between 98 and 102 and has been in service less than 2 years is painted, the register set back to zero, and the meter returned to service.

Attention is called to the fact that the test requirements of the Bureau for repaired meters are exactly those specified by this Association for new meters. No difficulty is being experienced now in repairing meters to pass these tests. Earlier in the program, as the test requirements were gradually stiffened, it was found that all models of certain makes of meters and certain models of other makes could not be repaired to pass the tests, unless an uneconomical amount of parts and labor was used. As these, in general, were meters which had been in service at least twenty years, it was decided to turn them in for new meters as fast as they were removed from service. New

TABLE 3.—SPECIAL TESTS ON NEW AND REPAIRED 5/8-IN. METERS

Rate in Gallons per Minute					Registration Starts
16	5	0.8	0.25	0.07	
		Disc Meters—Make A—New			
99.9%	101%	100%	99%	92%	0.01
99.6	101	100	98	88	
99.9	100	100	99	91	0.01
99.5	100	100	99	89	
99.7	100	101	99	90	
99.5	101	100	97	89	
99.8	100	100	99	91	
99.4	100	100	98	91	
		Disc Meters—Make B—New			
98.6%	100%	100%	99%	93%	
100.7	101	100	99	95	0.01
101.5	101	101	99	88	
100.1	101	100	100	96	0.03
98.5	100	100	100	92	
99.9	101	101	99	83	
99.3	100	100	99	19	
99.6	100	100	100	94	
		Disc Meters—Make C—New			
99.1%	101%	98%	95%	73%	
99.1	101	100	99	85	above 0.03
100.5	101	101	97	71	
100	101	101	99	86	0.03
100.2	102	102	96	74	
99.8	102	100	96	64	
100.1	101	102	98	84	
100	102	102	99	84	
		Piston Meters—Make D—Old Meters—New Chambers			
100 %	100%	102%	99%	90%	
99	101	100	97	72	
100	100	100	88	20	
100.2	101	100	96	40	
		Piston Meters—Make D—Old Meters—Remachined Chambers			
98 %	100%	99%	96%	70%	
99.2	100	99	91	54	
100.5	101	100	97	74	
		Rotary Type Meter—Make E—New			
101 %	101%	101%	98%	86%	

meters of good quality, whether disc or piston, give far better tests than those required under present specifications. As a matter of interest, complete tests of several makes of new meters are given in Table 3, together with the results of the same tests run on piston meters repaired in the Bureau shop.

Shop Methods. Early in the program for better meter maintenance, it was found desirable to prohibit all fitting on the repair bench and to limit the repairman's work to taking down, cleaning and reassembling the meter; replacing worn units, such as disc or chamber assembly, intermediate gear train, and register with other ready-assembled units, either new, or repaired elsewhere than on the meter bench. At first, all worn discs and chambers were sent back to the manufacturer, but lately it has been found advantageous to stock oversize discs for some makes of meters and to permit the man on the bench to install the oversize disc when necessary.

Intermediate gear trains and registers are taken down, the worn parts replaced with new, and the trains reassembled. Top and bottom plates of piston meter chambers now are being remachined satisfactorily in the Bureau shop. However, proper gages—preferably factory-furnished—plus a good lathe and a skilled mechanic are needed to obtain uniformly good results.

With repair and testing technique improved to the point where it can be said with confidence that every meter going into service meets all the requirements of this Association for new meters, and with this procedure in operation long enough so that it can be said truthfully that every small meter in the system has been in the shop for reconditioning within the last five years, it is desirable to attempt to answer the following questions:

1. What are relative costs of good meter maintenance and poor meter maintenance?

2. Is improvement in meter maintenance with consequent increase in meter accuracy, particularly on the low flows, reflected in increased revenue?

The first question is answered conclusively by the figures in Table 4.

The larger number of meters handled during 1935 and 1936 resulted from the special effort made to complete as soon as possible the reconditioning of all meters in the system which had been in service more than five years. It is to be noted that, while the total

TABLE 4—VOLUME AND COST OF METER WORK 1931-1939

Year	Total Number of Meters in Service All Sizes	Number Repaired and Tested at Shop	Number Tested on Premises	Total Cost	Cost Per Meter Repaired in Shop
1931	26,204	5,639	—	$33,418.04	$5.92
1932	26,587	4,774	281	30,376.42	6.35
1933	26,643	6,117	171	33,321.99	5.45
1934	26,668	6,334	302	38,643.06	6.10
1935	26,920	9,566	300	42,404.00	4.43
1936	27,365	8,564	194	43,916.00	5.13
1937	28,091	5,371	171	28,433.00	5.30
1938	28,603	5,819	163	27,806.00	4.77
1939	28,934	5,967	100	29,957.00	5.02

amount spent is roughly proportioned to the number of meters put through the shop, the gross cost per meter tends to *decrease* and not increase, despite more rigid repair and testing standards. In other words, it costs no more and perhaps a little less with the improved methods and facilities now available to do a good job of meter maintenance than was formerly paid for an inferior job.

Information at present available is not sufficiently complete of itself to warrant an exact answer to the second question, although studies which have been undertaken seem to point to the same general trend.

The years 1927, 1928 and 1929 are taken as a group and as typical of the period when relatively poor meter maintenance practice prevailed, and the years 1937, 1938 and 1939 are taken as a group and as typical of the period after present meter maintenance practice had been in operation for a considerable time.

Method A, a study to determine the comparative average revenue per person per year from the sale of water for domestic use only, indicates an increase in per capita revenue from $3.50 in the 1927-1929 period to $3.63 in the 1937-1939 period (3.7% increase). See Table 5.

Method B, a comparative study of water revenues from a group of representative premises all served by 5/8-in. meters, with conditions remaining practically unchanged, indicates that revenue per meter has increased 4½%. See Table 6.

Method C indicates that from 1928 to 1939 the percentage of unaccounted for water has been reduced from approximately 27% to 15% and that of the 12% reduction 7% is due to a general tightening up of the distribution system resulting from annual Pitometer surveys, leaving a balance of 5%, which can only be accounted for by improved registration of meters of all sizes. See Table 7.

TABLE 5—INCREASED REVENUE DUE TO INCREASED METER ACCURACY
Method A: Increase Per Person Supplied with Water

Year	Population Supplied	Revenue from Domestic Sales	Revenue Per Person Per Year
1927	201,000	$ 691,921.48	
1928	206,000	710,504.28	
1929	211,000	759,298.77	
	618,000	$2,161,724.53	Average $3.50
1937	243,000	$ 886,483.01	
1938	247,000	895,746.08	
1939	254,000	921,670.23	
	744,000	$2,703,899.32	Average $3.63
Increase 1937 to 1939 over 1927 to 1929 =			3.7%

Note: Population from Meter Readers' census and local directories. Revenue from Domestic Sales is assumed equivalent to water revenue from all sources, except Industrial Sales and Sales to Other Water Companies.

Although the results of the three methods are in general agreement and indicate a possible increase in water revenue of approximately 4% as a result of increased accuracy in meter registration, there are apparently other factors which considerably modify these indicated increases, to the extent that they are not reflected to the same degree in actual gross water revenue. The results, therefore, should be taken as a trend, indicating worthwhile economy, rather than as a precision measurement.

The present practice of the Bureau on the maintenance of meters larger than 2 in. is to require an accuracy of registration to meet the N.E.W.W.A. specifications so far as these apply, and on compounds and special types of large meters to require accuracy equal to that

TABLE 6—INCREASED REVENUE DUE TO INCREASED METER ACCURACY
Method B: Increase from 129 Premises Served by 5/8-in. Meters

Year	Billings 1st 6 Months	2nd 6 Months	Total
1927	$1,098.60	$1,094.40	$2,193.00
1928	1,089.75	1,024.35	2,114.10
1929	1,060.65	1,096.05	2,156.70
			$6,463.80
1937	$1,119.75	$1,090.80	$2,210.55
1938	1,119.60	1,093.35	2,212.95
1939	1,181.50	1,149.40	2,330.90
			$6,754.40
Increase 1937 to 1939 over 1927 to 1929 =			4½%

Note: From 400 premises, served by 5/8-in. meters in a section of the city showing little change in character of building or type of occupancy during the past 13 years, there was discarded any premise having a variation in bills of as much as 100% or having a minimum bill during the period. Data from the remainder (129) are given in Table 6.

of a new meter of its kind and type. All tests on meters larger than 2 in. are made in place, with rates of flow controlled by orifice under constant pressure, or by calibrated gate opening checked by stop watch. A skeleton test is made "as found" and a complete test "as left". Accuracy curves are plotted and compared with those from previous tests on those meters which are large revenue producers. Six-inch and larger meters are tested each six months; four-inch, once each year; and three-inch, once every two years, or oftener if use is large.

Sizing of meters has been carried along in parallel with better maintenance of the larger meters, so that increased revenue from this group of meters may be due to either one or a combination of both improvements in meter practice. In order to select the size of meter which best fits the demand pattern of the premise which it serves, it is necessary to obtain, first of all, data on the maximum and minimum and average rates of draft at the premise. These data can be obtained by an observer with a stop watch, by an instrument making a graphical record of the rate of revolution of one of the meter dials, or by thorough inspection of the premise followed by an estimate of rates

TABLE 7—REDUCTION IN UNACCOUNTED FOR WATER DUE TO INCREASED METER ACCURACY (*Method C*)

Year	(1) Delivered in City Venturi	(2) Accounted for by Pitometer Work	% (2) to (1)	% Unaccounted for Water % of (1)
	(Billion Gallons)			
1928	——	——	——	26.75
1929	6.4855	.0287	0.44	——
1930	6.8062	.0861	1.26	——
1931	6.5678	.1427	2.20	——
1932	6.3753	.1162	1.82	——
1933	6.3024	.0975	1.55	——
1934	6.7644	.0314	0.46	——
1935	6.6577	.0209	0.31	——
1936	6.9476	.0298	0.43	——
1937	7.0615	.0579	0.82	——
1938	7.0245	.082	1.10	——
1939	7.3502	.010	0.13	14.80
Reduction in Unaccounted for Water				11.95
Total accounted for by Pitometer work			10.52	
Less: Ordinary leakage developing from year to year			3.41*	
				7.11
Unaccounted for water reclaimed by improved meter registration (1928-1939)				4.84%

*Average ordinary loss through leakage developing each year, assumed to be 0.31%, based on the experience of the period 1934-39 inclusive. In figuring this average, abnormal leaks amounting to 0.64% (1937) and 0.72% (1938) were omitted.

from the observed use. The Bureau uses the second method almost exclusively as being more convenient and cheaper, and yielding more accurate information than either of the others.

An interesting compilation of some of these tests on the smaller meters, grouped by number of flushometer toilets, or number of tank toilets, is given in Tables 8 and 9. The same wide range of rates of flow into what are apparently very similar premises, which have been noted by others who have published the results of their investigations in this field, can be observed in this tabulation.

The sizing of the larger meters requires consideration of max-

TABLE 8—DATA USED IN SIZING SMALL METERS IN PREMISES HAVING FLUSH VALVES

Type of Building	Number of Flush Valves	Number of Faucets	Size of Service —In.	Size of Meter —In.	Rates of Draft (G.P.M.) Minimum	Maximum	Average
Single house	1	7	1	5/8	0	20	10
2-family house	2	16	1	3/4	0	25	8
Warehouse & store	4	24	1½	1½	0	20	5
Single house	5	24	1½	1	0.4	15	1
Miscellaneous stores	5	14	2	¾x1	1	20	1
Garage and shop	6	8	2	1	0.1	15	8
Factory	6	10	4	1½	0	15	1
Shop	8	6	2	¾x1	0	25	7
Police station	8	25	4	1½	0.3	35	15
Rooms and stores	10	34	2	1	1	20	5
Private house	10	50	4	1½	0	23	8
Home	10	22	4	1½	0	50	3
12 apartments	12	72	2	1½	0	20	3
12 apartments	12	72	2	1	0.2	30	5
Warehouse	15	18	2	1½	0	15	2
2 stores & hotel	15	40	2	1	0	25	2
18 apartments	18	108	1½	1	0	15	5
18 apartments	18	108	2	1	0.4	30	10
21 apartments	21	126	2	1	1	20	10
24 apartments	24	180	2	1	0.25	15	5
21 apartments	21	126	2	1½	0	25	8
24 apartments	24	144	2	1½	0	60	25
27 apartments	27	162	2	1	0.4	15	10
27 apartments	27	162	2	1	0.008	25	5
30 apartments	30	192	2	1½	0	25	10
30 apartments	30	195	1½	2	0.1	40	20
Burr school	40		4	2	0.6	60	10
42 apartments	42	252	2	1½	0	20	8
Hfd. Ct. Trust	50	140	2	2	5	75	17
Stores and apts.	57	332	4	2	2.5	40	15
Insurance office	60	150	4	2	0	75	25
County building	105	40	6	2	0.5	75	25

imum demand as well as data on actual rates of use. For instance, at one manufacturing plant, rates from a 3-in. meter indicated that a 2-in. meter would be ample, and the change was made. A few days later a complaint of lack of water came in from this plant, and investigation disclosed that it was their custom to empty and refill a large cooling tank once a week and that the rates of use were taken on a day when the tank was not being filled. The 3-in. meter was put back—with apologies.

Data on a few typical investigations of rates of use through large meters are given in Table 10, together with size of original meter and replacement size, and the net increase in water used at all the premises listed. In studying Table 10, it will be noted that results obtained by

TABLE 9—DATA USED IN SIZING SMALL METERS IN PREMISES HAVING TANK CLOSETS

Type of Building	Number of Closets	Number of Faucets	Size of Service —In.	Size of Meter —In.	Rates of Draft (G.P.M.) Minimum	Maximum	Average
Barn	1	1	¾	⅝	0	5	5
Single house	1	9	1	⅝	0	8	5
Single house	1	6	1	⅝	0.05	10	5
Church	1	13	1	⅝	0	10	5
2-family house	2	13	1	⅝	0	5	5
2-family house	2	16	¾	⅝	0	10	5
Garage	2	4	1	¾	0.3	15	2
Warehouse & stores	2	3	1	⅝	0.02	15	2
Fire house	2	9	1½	¾	0	20	10
Single house	2	19	1	¾	0	25	10
3-family house	3	24	1	¾	0.05	3	3
3-family house	3	24	1	¾	0.9	7	2
3-tenement	3	30	1	⅝x¾	0	10	2
Warehouse & stores	3	12	1	⅝	0	10	3
Single house	3	15	1	⅝	0.12	10	2
Miscellaneous stores	4	6	1¼	1	0.16	15	1
Store & 2-tenement	3	13	1½	1	0.25	25	7
Single house	4	20	1	⅝	0	8	4
Residence	4	20	1	¾x1	0	15	1
Club	5	12	1½	1½	0.1	8	4
6-tenement block	6	48	1	¾x1	0.05	5	2.5
6-tenement block	7	48	¾	¾	0.25	20	10
Miscellaneous stores	7	10	2	1½	0.2	75	5
6-ten., store, garage	8	50	1	1	3	10	5
4 stores	8	18	1½	1½	0	25	8
9 apartments	9	54	2	¾x1	0	20	4
Church, parish house	12	28	2	1½	0	20	1.5
12 apts. & 2 stores	15	76	1½	¾x1	0.5	20	8
15 apartments	15	90	2	1	0	25	15
Stores & apartments	15	40	1½	1	2.5	25	5
15 apartments	16	90	2	¾x1	0	30	8
Insurance office	20	60	2	1½	0	25	7

changing from a larger to a smaller sized meter vary widely. In some cases *less* water was registered by the smaller meter; in others, the replacement of a meter by another of the same size, or by a smaller meter, seemed to cause a very marked increase in water registered. Because of this wide variation, the net increase, figuring about 9%, should not be taken too seriously, except as an indication of trend. That this trend is toward a fairly substantial increase in revenue is borne out by studies of income return from groups of similar properties which are large users of water.

A group of nine home office buildings of insurance companies, which together use about $12,000 worth of water a year, gave the following results:

TABLE 10—DATA USED IN SIZING LARGE METERS

Type of Building	People	Apartments	Number of Flush Valves	Tanks	Faucets	Size "As Found" Meter—In.	Rates G.P.M. Max.	Rates G.P.M. Min.	Size "As Left" Meter—In.	6-month use "As Left" Meter cu. ft.	6-month use "As Found" Meter cu. ft.
Bank and office	125		12	11	106	4D	15	0	1½D	35,400	40,000
Apartment	70	32	—	32	256	3D	12	1.8	1½D	212,000	174,300
Telephone Co.	250		53		123	3C	75	2.0	2C	263,000	198,300
Hotel	70	120	40	20		3D	12	1.8	1½D	276,000	346,000
St. Mary's Home	250		9	38	192	3D	12	0	1½D	276,200	207,000
Hartford Hospital	100		20		250	3W	60	2.5	3C	575,000	475,000
Insurance Co.	700		48		138	3C	50	1.5	2C	280,000	253,000
Factory						3W	50	1.0	1½D	833,000	796,000
Drugs	85			6	18	3P			2C	76,300	86,700
Apartment	60	24	25		161	2D	25	0.3	1D	84,400	69,600
Mixed	60	12		15	55	2C	10		1D	75,000	66,000
Apartment	16			17	130	2C	10	0	1½D	55,200	52,800
Apartment	114	38	39		312	2C	25	0	1½D	150,000	162,000
Garage	40			4	17	2D	20	1.5	2C	138,000	111,900
Apartment	60	14	14		89	2D	30	0	1D	89,000	96,500
Factory	90		20		15	2D	18	0	1D	55,700	34,500
Hotel	89	60	14	2	285	2D	20	0.5	1½D	86,400	80,300
										3,560,000	3,249,900
										+9.56%	

Note: D=Disc
P=Piston
C=Compound
W=Wheel

4% more water used in 1937 than in 1927,
2½% more water used in 1938 than in 1928,
6½% *less* water used in 1939 than in 1929.

The same amount of water was used in the period 1937 to 1939 as in the period 1927 to 1929. No explanation has been found for this reversal of trend during the past year.

A group of five office buildings, using about $3,000 worth of water a year, gave the following results:
21% more water used in 1937 than in 1927,
5% *less* water used in 1938 than in 1928,
42% more water used in 1939 than in 1929,
18% more water used in the period 1937 to 1939 than in the period 1927 to 1929.

A group of four apartment buildings, using about $2,700 worth of water a year, gave the following results:
29% more water used in 1937 than in 1927,
2½% more water used in 1938 than in 1928,
14% more water used in 1939 than in 1929,
14½% more water used in the period 1937 to 1939 than in the period 1927 to 1929.

The two previous groups give about the same result, and it is interesting to note that in both groups the comparison of 1938 and 1928 gives the smallest difference.

A group of six laundries, using about $8,000 worth of water a year, gave the following results:
7½% *less* water used in 1937 than in 1927,
12% *less* water used in 1938 than in 1928,
5½% *less* water used in 1938 than in 1929
8% *less* water used in the period 1937 to 1939 than in the period 1927 to 1929.

These figures seem to indicate a slump in the laundry business, and this was confirmed by the operator of one of the laundries, who estimated that the laundry business as a whole had dropped about 10% from 1928 to 1938. This same laundryman stated that his own business had expanded 31% between the period 1927 to 1929 and the period 1937 to 1939, and that his water bill during the same interval had increased 48%, a difference of 17%. This last figure checks fairly well with the 18% increase at office buildings and 14½% in-

crease at apartment houses, and all these figures taken together constitute pretty definite proof that better maintenance and sizing of large meters have resulted in increased revenue. If this increase were 10%, the resulting increase in dollar revenue to the Bureau would be in the neighborhood of $15,000, which is much more than has been necessary to finance the improvement work on large meters.

In conclusion, the writer does not contend that the percentage improvement in accuracy or return in revenue due to improved meter maintenance and sizing of meters will hold, even approximately, for other water systems whose present meter practice falls short of that recommended by the N.E.W.W.A., but he does believe that if the figures given in this paper prove anything, it is that good meter maintenance and proper sizing of meters more than pay their own way in increased revenue.

CROSS-CONNECTIONS AND THE PLUMBING TESTING LABORATORY IN THE NEW BEDFORD VOCATIONAL SCHOOL

BY E. J. SULLIVAN*

[*Read April 25, 1940.*]

Following the outbreak of several water-borne epidemics in this country which were presumably due to the contamination of public water supplies, the Massachusetts Department of Public Health under authority contained in Section 160, Chapter 111, of the General Laws adopted rules and regulations under date of February 9, 1937 relative to cross-connections between public water supplies and fire and industrial water supplies. These rules and regulations were introduced for the purpose of eliminating the possibility of water obtained from a secondary supply or a supply of unknown quality reaching the distribution system of a public water supply.

The following list shows some types of cross-connections:

1. Fire service having pumps with suction connected to any open reservoir or to an underground reservoir and municipal water pipes connected to sprinkler systems.
2. Open reservoirs or underground reservoirs for suction of fire pumps, having municipal water mains entering below the water surface.
3. Open tanks, feeding sprinkler systems, having municipal water pipes entering below the rim. (These are usually emergency supplies feeding sprinkler systems in case of fire.)
4. Swimming pools with recirculating systems and submerged inlets.
5. Hydraulic elevators with recirculating systems.
6. Open vats with below-the-rim inlets.
7. Wading pools and fish ponds fed by municipal water at points below the surface.
8. Water ejectors for sumps and pits.
9. Gasoline stations using municipal water beneath gasoline to secure pressure at pumps.

*Assistant Engineer, Massachusetts Department of Public Health, Boston, Mass.

10. Recirculating systems for air-conditioning and cooling systems.

11. Washers in laundries fed by municipal water at the side or bottom of the washing machine.

12. Milk coolers in dairies.

13. Dye, bleach, hide-washing, or tanning wheels fed by municipal water at axis or below the rim without adequate air break.

14. Steamer connections on the outside of buildings when it is possible to connect them with a pump pond, river or other water of questionable quality into the sprinkler systems.

15. Municipal water pipes used to supply make-up water for open boiler-feed tanks, pump priming, etc.

16. Direct municipal water connections with sewers for sewer-flushing purposes, for draining sprinkler systems, or for a cooling system, or for emergency electric generators driven by water power, etc.

Because of the varying conditions existing in piping arrangements and at industrial plants, no one remedy is adequate to solve all cross-connection problems. The use of one or more of the following, after a careful study of the particular problem, can usually accomplish the desired end:

A. Approved double check-value installations on municipal water supply mains, drinking water being taken off on the street side of double checks or through separate lines from street mains. (New installations not permitted after December 31, 1937.)

B. Municipal water pipes ending 6 in. above the top of open tanks.

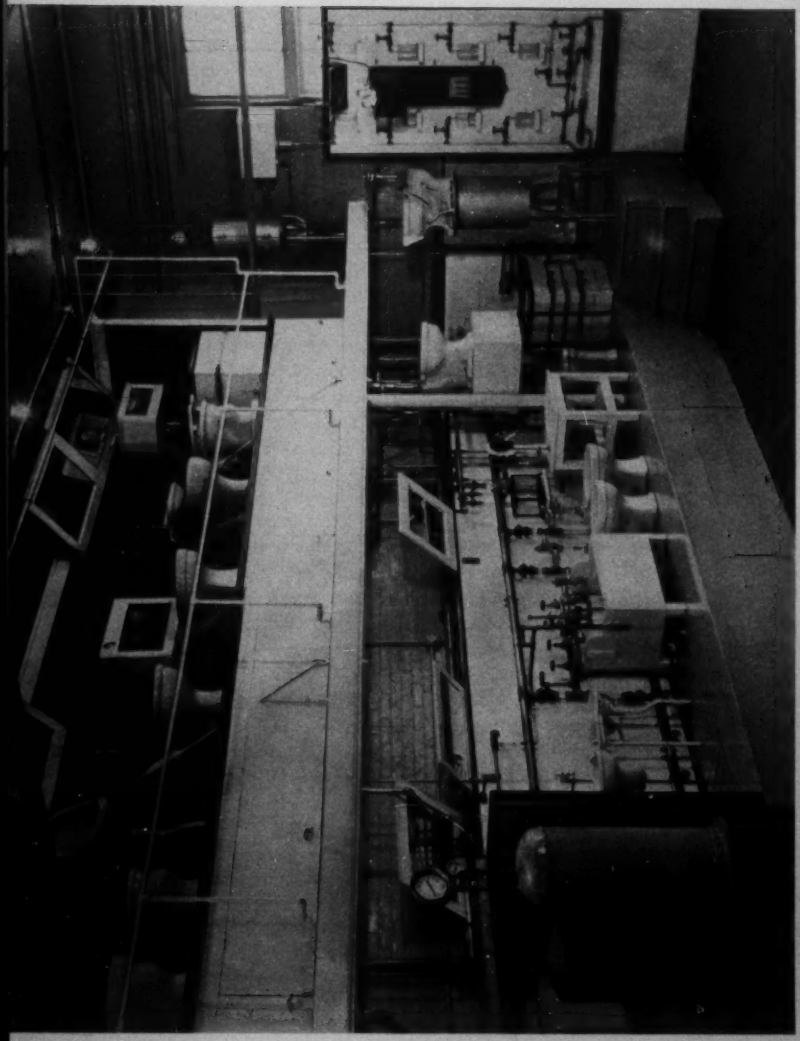
C. Indirect funnel connections having 6-in. air breaks.

D. Disconnection of fire pumps from sprinkler systems on approval of insurance companies.

E. Approved swing connections, provide all pipes carrying drinking water terminate 6 in. above the rim of all tanks supplied with water of questionable quality.

F. Siphon breakers of approved type for certain small cross-connections.

Surveys made by the Division of Sanitary Engineering of the Massachusetts Department of Public Health for the purpose of enforcing the rules and regulations of the Department disclosed the fact that a great many plumbing cross-connections existed within industrial



establishments, institutions and schools through which polluted water might enter the drinking water systems within the establishment, institution or school. While enforcement of the rules and regulations would eliminate the contamination of public supplies, it would not necessarily eliminate the possibility of contaminated water entering private piping systems.

The importance of proper plumbing fixtures, devices and connections to prevent the contamination of drinking water systems was hereby recognized. Assuming that the Department of Public Health would be requested from time to time to pass upon the adequacy of certain plumbing fixtures and connections, it was decided that a testing laboratory should be established so that fair and impartial judgment could be passed by the Department. With this point in view, a conference was held between officials of the Division of Sanitary Engineering of the Massachusetts Department of Public Health, the Water Department of the City of New Bedford, the State Association of Master Plumbers and the New Bedford Vocational School. After due consideration it was decided that such a testing laboratory might be established at the New Bedford Vocational School.

During the latter part of 1938, a laboratory was constructed at this school, and it has since that time been continually expanded. The main reason for establishing the laboratory at this location was the fact that instruction is given in the art of plumbing and heating installation to some fifty students of this school. These students are not only from New Bedford but from all of the southeasterly part of the State. Students have attended from as far distant as Marblehead and Provincetown. It was recognized that a great deal of helpful information could be obtained by these students from the exhibit of modern plumbing devices and the experiments and tests.

Extending along the easterly wall of the class room devoted to instruction, there has been constructed a raised platform about 2½ ft. above the floor and about 3 ft. wide. Beneath the platform and extending the entire length, there is a copper pan about 18 in. wide and about 6 in. deep with an outlet which discharges into the sewerage system. This pan or trough acts as an outlet for the discharge connections for the several fixtures and devices located on the platform. Near the northerly end of this platform there are a vacuum pump and a series of vacuum tanks, together with gages and a maze of piping and valves to provide flexibility. A 2-in. copper supply line containing

branch outlets, extends the entire length of the platform for the water supply connections to devices and fixtures. Parallel with this line and about 3 ft. above it, there is another similar 2-in. copper line along the entire length of the wall which may also represent the water supply line in ordinary construction. Another 2-in. copper line runs along the wall about 5 ft. above the platform, and this also contains several outlet connections. This line was installed for the purpose of supplying water to fixtures placed on a mezzanine floor. To facilitate the use of this exhibit the fittings on the water supply lines are painted red while the fittings on the vacuum lines are painted yellow.

At the northerly end of the platform there are a lavatory and three bubblers set at slightly different elevations. Each of these fixtures has an independent connection to the lower water supply line consisting of transparent pipe. A test tank which is approximately 3 ft. long, 2 ft. wide and 2 ft. deep is located near the center of the platform. This tank is used for testing and demonstrating the action of flushometer valves and vacuum breakers, the piping arrangement being such that each fixture and device can be operated independently. The tail pieces and valve connections on most of the flushometer valves consist of transparent Lucite piping. To the south of this tank is a battery of six toilet bowls of different characteristics. One of these toilets is connected to an elevated tank, another to a low tank. Both of these tanks are purposely of wooden construction, and a transparent face has been inserted in their front so that the action of the water and the flushing mechanism in the tanks can be observed. Two of the other toilet bowls are equipped with flush valves, the connections also being fitted with transparent pipe. Individual shut offs are inserted in the connection to each of these toilets so that they may be tested independently. To the south of the toilets is an elevated tank on the top of which is a toilet bowl, the outlet of the tank being so arranged that the water discharges into a miniature bath tub located on balanced scales. This installation was designed to determine the amount of water used for flushing purposes. Near the southerly wall and on the same platform is a set of scales with the miniature bath tub previously mentioned for the purpose of weighing water used by the different fixtures. This tub is provided with an outlet which discharges into the trough or tray located beneath the platform.

A half closet bowl cut so as to show its cross section is placed in the corner and is fitted with a transparent face and equipped with

a flushometer valve connected to the water supply so that the action in the bowl may be observed. A panel has been constructed on the south wall to represent the elevation of two 4-story buildings. The piping arrangements on this panel are such as to represent two typical water supply house systems. That on the right of the panel represents a building in which a considerable amount of water is used and the supply pipe to the building includes a fish trap, meter and bypass. On the left of the panel is represented the piping system of an ordinary building with the piping so arranged that a space is left for a meter, but no fish trap or bypass is provided. The piping system at the bottom of the panel represents corporation cocks, curb cocks, etc., which are regularly included in a service connection. In the center of the panel is a replica of an arrangement used many years ago for supplying water in a private house to the boiler and other fixtures from a storage tank in the attic. This fixture was in reality the control equipment used on gravity supplies, the source of which consisted of rain water collected from an elaborate arrangement of gutters, leaders, troughs, etc. In some instances the supply was from springs situated at higher elevations from which the water flowed to the storage tank by gravity. The control equipment in this fixture consists of weighted ball levers which close the outlet openings to the different systems, these levers being operated by ball-handled pulls which travel up and down through a vertical slot in the keyboard, the bottom of the slots being notched so that the pulls can be made to hold the valves in the tank open. Practically the entire piping on this panel consists of Pyralin or transparent tubing, the valves and fittings being of brass.

A vacuum, equivalent to 21 in. of mercury, can be applied to each of the 2-in. headers. With the use of a harmless vegetable dye the water is discolored so that with the large amount of transparent pipe inserted in the metal pipe connections the possibility of back siphonage can be demonstrated.

The mezzanine floor which has recently been installed is not wholly equipped, because it is thought advisable to have space for the installation of future equipment. It might be interesting to note that the carpentry work and electric wiring in the construction and lighting of this floor have been done entirely by the students in the Vocational School under the able supervision of their instructors.

An elevated platform has been constructed extending along the

entire length of this floor. Beneath this platform is a trough or pan similar to that on the lower platform for the purpose of receiving the discharge from the different plumbing fixtures and devices to be placed at this elevation. The contents of this trough are discharged through a galvanized pipe to the lower trough, which in turn discharges into the sewerage system.

Reading from right to left there are an instrument sterilizer and a battery of three toilets equipped with flush tanks, these flush tanks having two inlets, one inlet being below the tank, while a second inlet is supplied with water through a loop which extends above the top of the flush tanks. Next there is a toilet equipped with a flushometer valve, the source of water being supplied from a 2-in. line which extends to the roof of the building. Then there is a toilet equipped with a flushometer valve, the source of supply being from the water supply line extending along the lower platform, and next to this there is a urinal which is supplied with water from below the mezzanine floor. The last fixture is a small tank above which is a flush tank, the front of which is open, the piping arrangement from this tank being such as to supply water to several fixtures on the lower platform.

Mr. Stephen H. Taylor, Superintendent of New Bedford Water Department, Mr. James F. Murphy, Inspector for the New Bedford Water Department and Instructor in Plumbing at the New Bedford Vocational School, and Mr. William R. Mackintosh, Director of the New Bedford Vocational School, deserve a great deal of credit for the present setup at this laboratory.

LESSONS FROM FLOODS AND HURRICANE AT WARE, MASS.

BY GEORGE F. MERRILL*

[*Read January 18, 1940.*]

The works at Ware were constructed in 1887, with a large collecting well and forty-one 2½-in. tubular wells as the source of supply. Water is pumped against an average total head of about 270 ft. through the distributing system to a 1.5-m.g. reservoir located on Church Street about one mile from the center of the town. The distribution system contains about 17½ miles of cast-iron pipe with 155 public hydrants, 36 private hydrants, and about 1100 services.

The pumping station has been flooded twice; the first time in the flood of March 1936, when water flooded the main pump room floor to a depth of 3.25 ft. In the flood of 1938 the water flooded the main pump room floor to a depth of 9.25 ft. In each instance, the large collecting well was flooded and the areas in which the tubular wells are located, and the pumping station was out of service. The period out of service was 54 hours for the 1936 flood, and 80 hours for the 1938 flood. During this period, the supply for the town was taken from the service reservoir which was drawn down so that only about 4 ft. of water remained at the time the pump was started in the 1938 flood, at which time much water was lost through broken mains and service pipes; also much water was used in flushing lines that were out of service.

Under normal conditions, the ground water supply is safe, and chlorination has only been used at the time of the 1936 and 1938 floods. The pumping station is located in the valley of Muddy Brook, about three-fourths of a mile from the point where it joins the Ware River. The high-water marks at the pumping station are due to water backing up from the Ware River, as the river channel below Ware does not carry the water at as fast a rate as the flow of the river from the north. In each flood we called the State Department of Health at Westfield, and Clarence I. Sterling was able to loan a portable chlorinating outfit with the necessary equipment to set it up, and an engineer to assist in getting it properly set up.

*Superintendent, Water Department, Ware, Mass.

The following procedure was used in starting the pumping station when the flood water had receded so that the station standby pump could be operated. Before starting the pump, all main valves to the distribution system were closed, and a blowoff valve on the pump side of the main valves was opened. Then the steam pump was operated for about two hours and the water wasted through the blowoff. During this time, the chlorinator was started and samples of the water taken from the pump were tested for residual chlorine, which was about 1.5 p.p.m. on starting. In this way, no water was pumped to the distributing system until all tests showed the chlorine properly feeding at a uniform rate. During the flood of 1938 we also rigged up a barrel of H.T.H. solution connected by hose to the pump suction, so that in any case of trouble with the chlorinator, this could be used for chlorinating the supply. However, getting the pump back into operation was a small part of our trouble in the last flood.

The Ware River divides the town, flowing in a southerly direction. So about one third of the population lives on the south side of the river and the balance on the north side. The supply lines to the southerly side consisting of a 6-in. main on the East St. stone arch bridge and an 8-in. main on the South St. stone arch bridge, were both carried away when these two bridges failed, thus leaving the southerly portion of the town without water supply. It was also without electric light, power or telephone service. The bridges were carried away about 8 a.m. on Wednesday, September 21, 1938, and this section was without water supply for 40 hours, until we were able to cross the Ware River and operate valves to supply water.

On Thursday night, about 6 p.m. the writer, with a laborer, was able to cross the river in a boat, about a half mile above the town, and to turn on the water into this area. About 10 a.m. of this day I was able to talk, by a telephone rigged across the river, with the chairman of the Water Commissioners. He had men notify all residents in the southerly area to boil the water when it was turned on. Earlier in the day we had determined, by testing with gauges, that an 8-in. main, which was a part of the Ware Industries yard system or factory fire-supply system and crossed under the Ware River within the Company's property, was sound and holding pressure. So it was decided to supply the southerly side of the river through this main by taking out the discs from the check valves at the connection on East Street. The Ware Industries plant, formerly the Otis Company, is

supplied by three connections from the mains of the distribution system: one from South Street, one from Main Street (both on the northerly side of the river) and one on East Street on the southerly side of the river.

After taking out the discs from the East St. check valves all lines at the river crossings were back-flushed into the river, and then the whole area was flushed by one-way flushing, controlled by the gate valves, so that a thorough flushing covered the entire system. On starting the pumps on Friday, the whole area was flushed one way, to carry water showing by tests a good chlorine residual through all parts of the distribution system on this side of the river, and to the ends of all lines.

As soon as water went down so that our men could work, the 8-in. main was relaid on the South St. bridge over those portions of the arches which still remained, and connected at the corner of Maple and South Streets on Sunday, September 25. This connection enabled us to supply more than half of the south side with chlorinated water through the regular distribution system. On Tuesday, September 27, a timber trestle about 100 ft. long was built at the East St. bridge, and the 6-in. main relaid, so that the south side of the river could be returned to normal supply. The pipe laying was completed about 10 p.m. with the aid of a portable gasoline-driven electric-light generator.

During the period when there was no water supply on the south side, drinking water was supplied from the houses which got their supply from springs located on the mountain easterly of the town. Those in need of water came and carried it to their homes. A citizens' committee also delivered water to those in need. Another group also delivered water at many homes where it was needed for purposes other than drinking. The citizens on the south side also organized an emergency community form of government, elected a mayor, appointed police and watchmen, organized workmen to clear the streets, and opened a relief station at the American Legion headquarters building, where meals were served to the workmen and those in need. This group did much to relieve chaotic conditions in what they called "Woolenville", by using such facilities as were available for the benefit of the community.

The extent to which Ware was isolated by the flood and hurricane of 1938 will be more clear to you when you realize the length

of time that many of the utilities required to restore service. Electric lights were resumed in about a week, power at the pumping station in 18 days, telephone service in 10 days, and railroad freight service 28 days. It was necessary to send several messages by short-wave radio from amateur stations. But the hook-ups were slow, and there was some uncertainty as to whether or not the messages were received. As there were no lights, few radios were receiving, so that when replies were broadcast (as they were in many cases), we were not able to receive them. Lack of electric power at the pumping station caused much extra work, as our pumps that were ordinarily automatic by electric power, had to be operated by gasoline pumps. Light was supplied at the pumping station by a portable gasoline electric-generator set, which was a great help.

I believe that any pumping station which operates many small motors for auxiliary services should have a small gasoline-driven electric-generator set, which will operate such motors for emergency use. In operating under hurricane conditions, it is essential that trucks be supplied with enough small-tool equipment which is not ordinarily carried—including axes, crosscut saws, ropes, chains, etc. We found that in many cases the men had to chop out tree tops, in order to find and operate valves. If you have to remove check-valve discs from the Factory Mutual check valves, be sure that you have a square socket wrench of the size required for this work, thus saving much delay.

One of the outstanding lessons of the two floods is that any plant such as a pumping station on which so much depends should either be protected by permanent bulkhead walls and dikes so that it will not be flooded, or built at a high enough level for that protection.

Another very obvious conclusion is that at least one river crossing should be developed, which is of large enough capacity, and protected so that it will withstand any flood, to insure a supply where a town is so situated as Ware.

We carried on, and probably did some things which are somewhat out of line from the point of sanitary engineering. However, with all the flood and hurricane misery endured by those whose houses were flooded or washed away, and loss and inconvenience to many, there were no loss of life and no sickness other than that caused from exposure.

The Water Department of the town of Ware desires to express

its appreciation to the State Department of Health for the valuable and timely assistance rendered in both the 1936 and 1938 floods by Arthur D. Weston, Chief Engineer, Francis H. Kingsbury, Clarence I. Sterling and the other engineers of the Department of Health during the emergency in each flood.

The Water Department of the town of Ware also desires to express its appreciation to the Metropolitan District Commission for the assistance rendered by their engineers Robert Stevens and Mr. Collingsworth during the 1938 flood.

EXPLOSIVES—TYPES AND USES

BY C. H. BLOCHER*

[*Read March 21, 1940.*]

There are five types of commercial explosives or dynamites which are most generally used in various types of construction work. They are as follows:

1. *Straight Dynamites.* Straight dynamite is the standard explosive in comparison with which all other high explosives are rated for strength on a weight for weight basis. The principal characteristic of straight dynamite is its quick shattering action, which increases with its strength. Straight dynamite is a most efficient explosive for submarine blasting, ditch blasting by propagation, mud-capping boulders and scrapping old machinery, boilers, ships, etc., where quickness is the essential quality. It is more sensitive than other types and the sensitiveness increases with the strength.

2. *Gelatin Dynamites.* The explosive base of gelatin dynamites is a jelly made by dissolving a special grade of nitrocotton in nitroglycerin. Two types of gelatin are manufactured today: one in which nitrocotton and nitroglycerin are the only explosive ingredients, known as straight gelatin, and one in which a part of the nitroglycerin is replaced by ammonium nitrate, known as ammonia gelatin. The DuPont brand name for the former is DuPont Gelatin, and for the latter DuPont Special Gelatin. In execution, they are much alike. Both types are dense, waterproof and plastic. The plasticity of the gelatin dynamites make it possible to load them solidly in bore holes, and thus to minimize the loss of force that is caused by air spaces in the charge, and under good confinement their high velocity gives them a strong shattering action.

These two characteristics, combined with the density, make the gelatins most effective in hard, tight work; in operations where a maximum shattering effect is desired and also in all varieties of wet work and submarine blasting. Also these types are most generally used in trench ledge excavations.

Gelatin dynamite is recommended especially for tunnel driving

*Explosive Division, E. I. duPont de Nemours Co., Inc., Boston, Mass.

as it is the best type of explosives for loading in uppers such as are commonly used in stopes as it sticks well in these bore holes and does not run out.

Gelatin should never be used for mud capping because when shot without proper confinement its action is relatively slow.

3. *Red Cross Extras.* In this type of dynamite, part of the nitroglycerin is replaced by nitrate ammonia. Not being as quick and shattering as the corresponding grades of straight dynamite, ammonia dynamite is better suited for work in soft rock, hard rock where a shattering action is not desired, and in sand, clay and earth excavation. Also in blasting frost and a great deal in stump blasting. While it does not stand water as well as straight or gelatin dynamite, it can be used in wet holes if the blast is fired within four to six hours.

4. *Gelex Nos. 1 and 2.* These are semi-gelatin dynamites; *i.e.*, although their chief explosive ingredient is ammonium nitrate, they also contain a certain percentage of nitroglycerin gelatinized with nitrocotton which makes them cohesive, gives them greater water resistance than the ammonia dynamites and decreases the volume of poisonous fumes. While they approach gelatin dynamites as regards fumes and water resistance, they are considerably bulkier than the gelatins.

Gelex No. 1 averages 105 cartridges 1¼ by 8 in., to the 50-lb. case and has a bulk strength of 60%. Gelex No. 2 averages 122 cartridges and has a bulk strength of 45%. They have proved satisfactory and economical in many kinds of work previously done with ammonia gelatin ranging from 35% to 60% strengths, or with 40 or 60% high density ammonia dynamite, chief among which are quarrying, limestone and gypsum mining, metal mining, and tunneling through limestone.

Gelex Nos. 1 and 2 will not give as good results in every operation as the older higher density explosives, but they do lower costs in many kinds of blasting.

5. *Nitromon.* The DuPont Company has developed a blasting agent for quarries which sells under the trademarked name "Nitromon".

"Nitromon" consists of a mixture of materials, including ammonium nitrate, which is packed in tin cans, each of which is provided with a triangular shaped bail at the top to permit lowering the cans by hook and line into bore holes. "Nitromon" differs radically there-

fore, in both properties, and appearance from any material used for blasting heretofore.

Among several advantages of "Nitromon", the safety of handling and use is probably the most important. It is not an explosive in the accepted sense of the word, since it cannot be detonated by (1) the strongest of commercial blasting caps; (2) "Cordeau" or "Primacord"; (3) flame; or (4) impact of a rifle bullet or of a heavy steel well-drill bit. Its full blasting strength is developed however, by the use of a suitable primer; a special type containing "Nitromon" and T.N.T.

Other of the most important advantages may be briefly stated as follows: (1) "Nitromon" is packed in tightly sealed metallic containers and as a result its water resistance is unlimited, provided the cans are properly handled and loaded; (2) it is non-headache producing not only because of the nature of its package but primarily due to the fact that it contains no nitroglycerin; (3) it is absolutely not-freezing; and (4) it shows appreciable savings to the purchaser.

Unfortunately this explosive is not manufactured at the present time in smaller than 4 by 24 in. cans and therefore is only available to large quarry operations where they use the well-drill method of blasting.

There are also some 15 or more types of "permissible explosives" which are used in the mining of coal. All these types have to be tested and passed by the Bureau of Mines before they may be used in any coal mine.

We now come to the latest development in the explosive field, and that is a new type of detonating fuse which has been given the trade name "Primacord". This fuse is used in firing a series of any number of well-drill holes in large quarries. It is used in connection with the special primer for "Nitromon" and is placed the entire depth of the hole where the primer is placed on the bottom of hole. Then each hole is connected to the trunk line and fired with an electric blasting cap. The speed of the new fuse is 20,300 ft. per second, or the fastest fuse manufactured to date. The explosive core of "Primacord" is called P.E.N.T. This fuse is much lighter in weight than the old lead tube of "Cordeau" and only weighs 15 lb. per 1000 ft. as compared with 98 lb. per 1000 ft. of "Cordeau".

REAL ESTATE ACQUISITIONS FOR METROPOLITAN BOSTON'S WATER SUPPLY IN THE SWIFT RIVER AND WARE RIVER WATERSHEDS

BY JAMES A. CHRISTENSON*

[*Read November 16, 1939.*]

INTRODUCTION

Quabbin Reservoir, situated about 65 miles west of Boston in the upper portion of the Swift River watershed, is soon to become one of the permanent geographical features of Massachusetts, replacing with its differing beauty and utility the former homesteads and villages which so recently were apparent fixtures of the region. The adaptation of this region and of the upper portion of the Ware River watershed for the collection and storage of potable water, and its distribution through Quabbin Aqueduct to Wachusett Reservoir was commenced in the late months of 1926 under the direction of Frank E. Winsor, Chief Engineer, a past President of this Association, and continued under his direction until his death on January 30, 1939. Since that time it has been under the direction of Karl R. Kennison, present Chief Engineer. The period covered by this report terminates on May 31, 1939, the date of the most recent financial statement, conveniently available. It is through Mr. Winsor's suggestion, made several months before his death, that a report of this nature is written, and it is regretted that the account must suffer from the lack of his keen criticism and helpful comment.

The purchase of real estate for this particular project has been a comparatively high element of cost, representing about 24 per cent of the total cost. It will be shown that this is accounted for by extensive purchases for water supply protection, and not because of exceptionally high prices paid for individual parcels. The extent of land requirements was never rigidly fixed, and purchases have been made within both the Swift and Ware watersheds at considerable distances from the point of intake provided the price has been low. This was resulted in unusually large controllable areas with the resultant assurance of safeguarding the purity of the waters which enter the storage

*Senior Civil Engineer, Metropolitan District Water Supply Commission, Boston, Mass.

and distributing systems. The general practice of the Metropolitan District Water Supply Commission with respect to real estate purchases will be reviewed and matters of organization, mapping and taking methods, as well as other topics of interest, will be discussed in the following order:

Swift River Watershed
Ware River Watershed
Quabbin Aqueduct
Rutland-Holden Sewer
Ware-Swift Watershed—Quabbin Aqueduct
Real Estate Purchases
  Organization
  General Procedure
  General Taking
Real Estate Costs
Taxation
Cemetery Removals etc.
Quabbin Park Cemetery
Cemetery Costs
Historical Notes

An appendix containing, as matters of general interest, reproductions of forms used for real estate and cemetery work together with miscellaneous records and tables, is included.

Swift River Watershed

The Swift River, with its three principal tributaries, the West,

Fig. 1.—Upstream Face, Winsor Dam.

Middle and East branches, is in the drainage basin of the Connecticut River. It flows in a general southerly direction to its junction with the Chicopee River at Bondsville, which is about 18 miles from the junction of the Chicopee River with the Connecticut River. About 5 miles upstream from Bondsville, Winsor Dam (Fig. 1), so named by the Commission on February 2, 1939, has been constructed. This, with Quabbin Dike (Fig. 2), an embankment carried across the valley

FIG. 2.—DOWNSTREAM FACE, QUABBIN DIKE.

of Beaver Brook, another tributary of the Chicopee River, have become the barriers which form Quabbin Reservoir.

The watershed of the Swift River above Winsor Dam plus that of Beaver Brook above Quabbin Dike amounts to 186.0 sq. miles. Quabbin Reservoir will, when full, occupy 38.6 sq. miles or 21 per cent of the total watershed. The water supply draft from Quabbin Reservoir is limited by the necessity to release enough water to maintain 20 m.g.d. at Bondsville, a short distance downstream, and by other releases during droughts to satisfy the requirements of the War Department for navigation in the lower Connecticut River.

Purchases in the Swift River watershed are still being made and are under consideration, so that the final total acquisitions are not known. It is predicted that about 81,000 acres will be acquired, or

about 67 per cent of the watershed, of which 80,135[1] acres are now in the possession of the Commonwealth. These purchases are, generally speaking, massed in the south and west portions of the watershed, and that portion of the watershed nearest to the aqueduct intake has been completely absorbed.

The East Branch Baffle, which artificially forces the flow received from a part of that branch and from the Ware River, for the purpose of longer storage, to travel 9 additional miles, incidentally increased the distance along the drainage to the intake from certain areas by the same amount. Lands in the southerly portion of Petersham which were actually about 6 miles from the intake, became by virtue of this barrier, about 15 miles distant and consequently purchases in this region were limited. Additional protection of the watershed is gained through the ownership of large areas of forest land by Harvard University, about 2,000 acres, and Department of Conservation, about 2,150 acres. Much of the remaining property in the town of Petersham has been developed into country estates occupied mainly in the summer months, and is of negligible detriment to the water supply.

About 242 miles of highways have been abandoned. In their place about 36 miles of new highways have been constructed: the Daniel Shays Highway on the west, the Ware-Belchertown Road on the south, the New Salem-Petersham Road (Fig. 3) on the north and a portion of the Petersham-Hardwick Road on the east. These new highways adequately care for general and through traffic which formerly entered and crossed the Swift River Valley. For highway location purposes, generally strips of land 80 feet in width were taken in fee. In cases of exceptional cuts or fills, slope easements were secured of sufficient widths. Additional land was also acquired at stream crossings, where needed.

Fourteen towns have been affected to a greater or less extent by the creation of Quabbin Reservoir. The reservoir itself occupies some portion of 10 of these towns, and because of extreme requirements for purposes of the reservoir, 4 of these towns ceased to exist as political units on midnight, April 27, 1938. The entire area of these 4 towns has been transferred to adjacent governmental units in the manner shown in Table 1.

[1]Settlements completed for 74,823 acres.

FIG. 3.—PETERSHAM-NEW SALEM HIGHWAY.

TABLE 1.—ANNEXATIONS TO TOWN AND COUNTY, APRIL 28, 1938—ACRES

Original Town and County	Hampshire County			Worcester County		Franklin County	Total Acres
	Belcher-town	Pelham	Ware	Hardwick	Peters-ham	New Salem	
Prescott							
Hampshire	—	—	—	—	138	11,525	11,663
Enfield							
Hampshire	1,699	1,368	4,695	—	—	3,500	11,262
Dana							
Worcester	—	—	—	—	12,132	—	12,132
Greenwich							
Hampshire	—	—	2,502	607	6,567	2,934	12,610
	1,699	1,368	7,197	607	18,837	17,959	47,667

The former inhabitants have scattered to various localities, but it is believed that a large percentage have moved to nearby towns such as Athol, Belchertown, Brookfield, Ware, Amherst and Palmer. The population of the four abolished towns is listed in Table 2 in accordance with the original town limits and corresponding to the recent annexations. The estimated percentage of the population added to adjoining towns is included to provide a basis for comparison with past censuses.

TABLE 2.—ESTIMATED SUBDIVISION OF POPULATION, 1930 CENSUS, CORRESPONDING TO THE AREAS INTO WHICH THE ABANDONED TOWNS OF DANA, ENFIELD, GREENWICH AND PRESCOTT HAVE BEEN SUBDIVIDED FOR ANNEXATION TO ADJOINING TOWNS
ESTIMATED POPULATION 1930

Town	Original Town Limits	Present Town Limits
Dana	505	100% to Petersham
Enfield	497	8% to Belchertown
		58% to New Salem
		31% to Ware
		3% to Pelham
Greenwich	238	10% to Hardwick
		16% to New Salem
		64% to Petersham
		10% to Ware
Prescott	48	100% to New Salem
Belchertown	3,139	3,179
Hardwick	2,460	2,484
New Salem	414	788
Pelham	455	470
Petersham	660	1,317
Ware	7,385	7,563
	15,801	15,801

In the report of the Joint Board consisting of the State Department of Public Health and the Metropolitan District Commission relative to water supply needs and resources of the Commonwealth, House No. 1550, January, 1922, it was brought out that the choice of the territory recommended for the site of Metropolitan Boston's water supply in the Swift River watershed was governed in part by the decreasing population trend in the vicinity. The report also showed that assessed valuations of real estate in the 6 towns most seriously affected was consistently increasing and gave figures for the years 1901, 1914 and 1920.

Figure 4 shows a comparison of valuation on a percentage basis, using the year 1919 as 100 per cent, between the 4 towns most drastically effected, Dana, Enfield, Greenwich and Prescott and 4 nearby towns of similar character, Granby, Leverett, New Braintree and Wendell. It shows that in the 4 towns not influenced by Quabbin Reservoir the valuation trend has been steadily upward, but that in the 4 Quabbin Reservoir towns a drastic upward trend occurred in

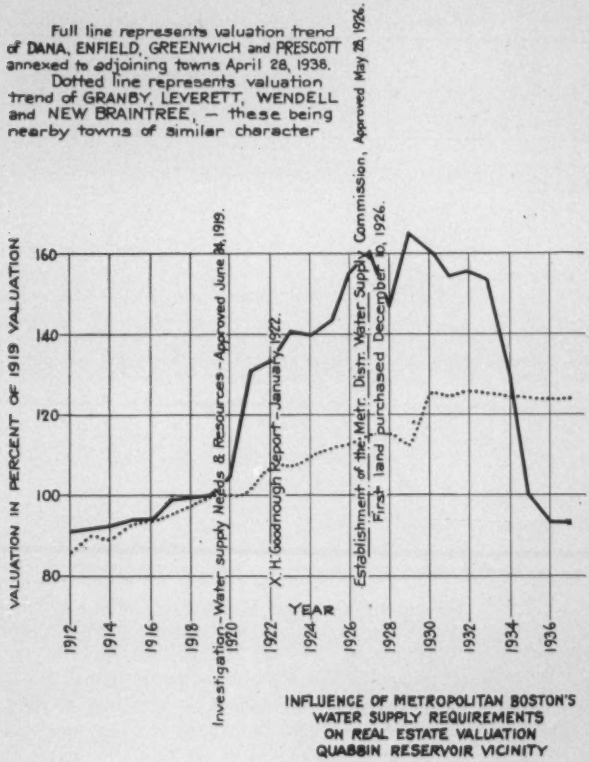

Full line represents valuation trend of DANA, ENFIELD, GREENWICH and PRESCOTT annexed to adjoining towns April 28, 1938.
Dotted line represents valuation trend of GRANBY, LEVERETT, WENDELL and NEW BRAINTREE, — these being nearby towns of similar character
VALUATION IN PERCENT OF 1919 VALUATION
160
140
120
100
80
1912
1914
1916
1918
1920
1922
1924
1926
1928
1930
1932
1934
1936
YEAR
Investigation-Water supply Needs & Resources-Approved June 24, 1919.
X. H. Goodnough Report-January, 1922.
Establishment of the Metr. Distr. Water Supply Commission, Approved May 28, 1926.
First land purchased December 10, 1926.
INFLUENCE OF METROPOLITAN BOSTON'S WATER SUPPLY REQUIREMENTS ON REAL ESTATE VALUATION QUABBIN RESERVOIR VICINITY

FIG. 4.

1920 after the investigation of the water supply needs and resources of the Commonwealth was ordered. This sharp rise continued until the year 1929 when the Commission's activities had made its definite imprint on the situation.

The Joint Board also reported regarding the character of land and buildings within the proposed reservoir area. The following two lists were included in that report and are reproduced here to show

conditions existing in 1922 prior to the formation of the Metropolitan District Water Supply Commission:

	Number		*Acres*
Mill structures	14	Orchards	51
Stores in use	38	Pasture and open land	2,118
Churches	6	Swamp and meadow	2,338
Schoolhouses	13	Scrub and young growth	7,889
Other public buildings	2	Timber land	6,845
Railroad stations, freight houses, etc.	14	Water surfaces	1,233
		Cemeteries	11
Houses, occupied	463	Unclassified land such as village and cultivated land, highways and railroads	4,385
Houses, vacant	30		
Barns, in use	381		
Barns, vacant	18		
Camps and summer cottages	61		
Total	1,040		24,870*

*24,700 acres actual area of Quabbin Reservoir.

Ware River Watershed

The Ware River, like the Swift, is also tributary to the Chicopee and the Connecticut rivers. The upper portion of it, draining an area of 96.8 sq. miles, is intercepted at Coldbrook, about 51 miles west of Boston, for the diversion of flood waters into Quabbin Reservoir (Fig.

Fig. 5.—Coldbrook Intake of Ware River, Shaft 8.

5). Withdrawals are limited to flows above 85 m.g.d. during the period extending between October 15 and June 15, in accordance with War Department regulations. Such withdrawals have been made when needed since March, 1931, for direct delivery to Wachusett Reservoir. Now that Quabbin Reservoir is ready, it will receive the benefit of subsequent diversions.

The first interception of the flow of the Ware River at the Coldbrook Intake Works was made in time to avert a serious water shortage, work on this structure and the tunnel connecting it with Wachusett Reservoir having continued despite the suit of the State of Connecticut before the Supreme Court of the United States which was decided in favor of the Commonwealth of Massachusetts on February 24, 1931. This legal obstruction was not permitted to change the policy of real estate purchases, and it apparently did not retard the progress of settlements. The great publicity created by this case may have been a responsible indirect factor in hastening the decision of some owners to submit their offers for consideration.

Purchases in the Ware River watershed above Coldbrook have been made generally with the intention of providing adequate protection at moderate cost. Extensive purchases were made in the vicinity of the Ware River Intake Works, including the entire village of Coldbrook, practically all of the territory located above it on Muddy Pond Brook and also above it on the Ware River as far as Barre Falls. Most of the recreational and all of the industrial properties located within the drainage area above the point of diversion have been purchased. Developed or potential sites of water power development have been generally acquired in their entirety. In the more remote portions of the watershed, farms and woodland properties bordering the Ware River or its tributaries have been freely purchased after much of the woodland had been cleared. Therefore they were obtained at nominal prices. There have been purchased in this watershed 14,689 acres representing 24 per cent of the total area above the intake works at Coldbrook. Other land may be acquired, particularly in the lower region, and an estimated total area of 18,366 acres may be reached, amounting to about 30 per cent of the watershed.

No governmental functions were disrupted in this locality. The displacement of several important industries, the loss of some recreational properties, and the removal of extensive land areas from

private ownership and occupation have caused a noticeable reduction in the activities of several towns, particularly Oakham and Rutland.

No storage reservoirs are necessary on this watershed, and practically all land acquired is available for forestation. Considerable work of this nature has already been accomplished.

Quabbin Aqueduct

The Quabbin Aqueduct Tunnel (Fig. 6), divided for convenience

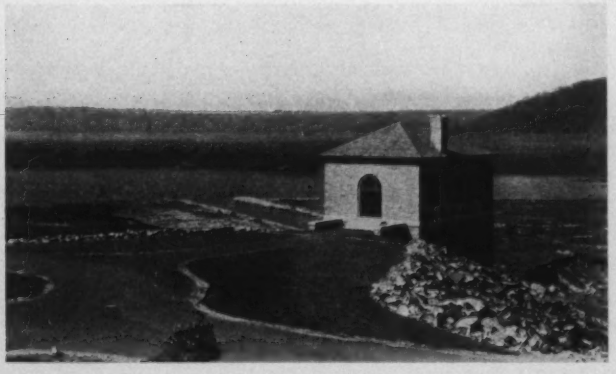


Fig. 6.—Quabbin Reservoir Headhouse, Shaft 12.

into the Coldbrook-Swift section, west of the Ware intake and the Wachusett-Coldbrook section east of the Ware intake, extends in one bore from Quabbin Reservoir (Elev. 530) easterly, passing under the intake works at Coldbrook (Elev. 657) to the outlet works at Wachusett Reservoir (Elev. 395). It is 24.61 miles in length and land taken for its construction amounts to about 1,115[2] acres. A 50-ft. wide strip was generally taken. At shaft sites sufficient land was taken for all construction and sanitary purposes. Within the watershed of Quabbin Reservoir and in the immediate vicinity of Coldbrook in the Ware watershed the taking included, except in a few cases, all land which would ultimately be needed for protection.

In this detailed analysis all lands taken for the aqueduct regard-

[2]Of this area 419 acres and 85 acres are credited in weekly and annual reports to the Swift River and Ware River watersheds.

less of location or purpose are classified as aqueduct property. In other reports, as for instance the annual reports of the Metropolitan District Water Supply Commission, lands taken for the aqueduct located within the Swift River and the Ware River watershed have been credited to the watershed of which they were a part, and to which they give protection. A full discussion of the construction of this aqueduct is contained in a paper entitled "Boston Metropolitan Water Supply Extension" presented before this Association by Karl R. Kennison.[3]

Rutland-Holden Sewer

On July 11, 1933, a taking of lands in the towns of Holden and Rutland was made for the Rutland-Holden sewer. This sewer, completed the following year, is about 9.5 miles in length, and is practically all located within the limits of the Wachusett watershed. Its purpose was the diversion of sewage from the Ware and adjoining Quinapoxet River and Wachusett Reservoir watersheds into the sewerage system of the city of Worcester, and its cost is charged to the protection of the Ware River watershed.

For the ordinary purposes of this sewer, a permanent easement 15 ft. in width was taken. This was usually flanked on both sides by 12.5-ft. strips in which temporary easements were taken for construction purposes. At points of exceptional fill requirements, additional land to a maximum width of 140 ft. was taken. A total of 23[4] acres of permanent easement was taken for this sewer.

Two serious sources of pollution were removed immediately from the Ware River watershed by the construction of this sewer: the Rutland State Sanatorium and the United States Veterans Hospital. This trunk sewer is designed to permit future connections by the towns of Holden and Rutland, which when completed will eliminate as sources of pollution, Holden Center, Jefferson Village and Rutland Center. A large percentage of the industrial wastes of the Jefferson Manufacturing Co. can also be diverted to this system.

All land required for the purposes of the sewer systems of Holden and Rutland will be acquired by the respective towns. The Metropolitan District Water Supply Commission has through its engineering department, designed the systems and prepared all contract plans

[3]This Journal 48 (1934), 147.
[4]Settlements completed for 21 acres.

and specifications. It will, under present arrangements, supply all equipment, supplies and materials and will furnish supervision and inspection. Labor will be furnished through local W.P.A. agencies.

The Ware-Swift Watersheds and Quabbin Aqueduct

While the construction of the Quabbin Aqueduct was under way, purchases were being made within the Ware River watershed and within the Swift River watershed for future construction activities and for the protection of both of these watersheds. When necessary for construction purposes, land takings were made, but as a general practice, purchases were the result of voluntary offers by the owners. The Ware River watershed linked with the Swift River watershed by means of the Coldbrook-Swift section of Quabbin Aqueduct gives Quabbin Reservoir, with certain reservations, the benefit of a drainage area of 282.8 sq. miles. The total property acquisitions in both watersheds will amount to about 55 per cent of their combined area.

Thus an unusually large ratio of protective lands to water surface has resulted. Compared with Wachusett Reservoir, the values are as follows:

Reservoir	*Water Surface* Sq. Miles	*Protective Lands* Sq. Miles	
Wachusett	6.46		5.86
Quabbin	38.60	Swift Ware	117.65

For the purposes of the cost studies which will follow, Quabbin Aqueduct, the Ware River watershed and the Swift River watershed are to be considered separately and in various combinations. This has been done to allow comparison with other works of similar character.

Real Estate Purchases

Organization. The Metropolitan District Water Supply Commission, originally composed of Davis B. Keniston, Chairman, Charles M. Davenport and Joseph M. Soliday, and which through changes from time to time now consists of Eugene C. Hultman, Chairman, Thomas D. Lavelle and Edward J. Kelley, has been the purchasing body. Acting through its Secretary, R. Nelson Molt, it has directed the appraisal, purchase and protection of the property acquired. Har-

vey E. Weir of Newton and Weir, Attorneys, has served as conveyancer from the beginning of the work. Former Chief Engineer Frank E. Winsor directed the investigations and surveys necessary and made recommendations and reports regarding the purchase of all properties which have been offered for sale to the Commission, until his death. Since that time, these duties have been carried on by the present Chief Engineer, Karl R. Kennison.

General Procedure. Since the beginning of the work in November, 1926, and until March 28, 1938, when the general taking of property in the Quabbin Reservoir area was filed, practically all purchases of real estate in this region had resulted from voluntary offers by individual owners. A few exceptions were directed court awards, or findings by the Board of Referees which had been established in accordance with the provisions of Chapter 321 of the Acts of 1927. The remaining exceptions were, takings by eminent domain for construction purposes. Since the general taking, settlements have continued in the same manner, but efforts have been made to secure listings from owners who had neglected to submit voluntary offers. The taking and notice of taking which was sent to owners who had not listed their property was the only large scale, aggressive, buying act of the Commission.

In the Ware River watershed practically all of the purchases made prior to the completion of the aqueduct and the intake works

FIG. 7.—GREENWICH VILLAGE, QUABBIN RESERVOIR.

at Shaft 8 in 1931, were made aggressively. Expediency did not permit the moderate procedure which was practiced in the Swift River watershed. Later purchases for protection of the Ware River watershed have resulted from voluntary offers. A view of the Quabbin Reservoir area is shown in Fig. 7.

Forms for the listing of property were available at a number of places in the region of the proposed reservoir and in the Ware River watershed. Listings were received by the Secretary and referred to the Chief Engineer, who, in turn, secured a report from the Division Engineer in whose jurisdiction the property was located. This report included a locality sketch and a statement regarding the extent and character of the property and its latest assessed valuation. If located in the Ware River watershed, a statement regarding its proximity to water courses was included. With this information available, a recommendation was made by the Chief Engineer and presented to the Commission, whose decision as to purchase resulted in rejection or acquisition.

The first offer received by the Commission, dated October 21, 1926, was from Alice G. Parsons, and covered property in Enfield and Greenwich. Settlement for this property was reached on February 24, 1927. The first settlement made by the Commission was with Jeff D. Roberts for property in Dana and Petersham, and was made on December 10, 1926.

Property listings reached a total of 2,237 in the Quabbin Reservoir area, and 361 in the Ware River watershed. Some of these were duplicate offers because some persistent sellers refused to accept rejections as final. Many of these listings covered lands which were not required, the number reaching 146 in the Quabbin Reservoir area and 81 in the Ware River watershed area.

The Commission employed a number of local men on a per diem basis as appraisers, three of whom investigated and made an independent appraisal of every property offered for sale. With this information available, the Commission's purchasing agent was authorized to negotiate with the owner. Normally the owner's offer would exceed the average appraisal figure, and our records show that the old Yankee dickering spirit still prevails in this neighborhood. George W. Cook, now deceased, Guy C. Allen, and Walter E. Clark, all well known and respected in the region, have served as purchasing agents.

Among the early activities which proved of great advantage to

those closely concerned with the real estate work was the rapid collection of deed abstracts covering the properties in Enfield, Greenwich and Prescott, an aerial survey covering the entire region under consideration, and the progressive collection of photographs of buildings in the reservoir area. Title examinations covering the remaining territory in both watersheds continued as required, the aerial survey became the base for the original locality and progress maps, and the building photographs were often available for immediate examination. Close cooperation has been maintained from the beginning between the Secretary, the Conveyancer and the Chief Engineer, resulting in a minimum of delay in reaching settlements with owners.

A system of plane rectangular coördinates was established, based on methods of the U. S. Coast and Geodetic Survey which was used as a control for all real estate surveys. Plans, scale 1-in. = 200-ft., were made showing all buildings, lot boundaries, their dimensions and type, lot areas, classification of land, and the extent of water surfaces. These plans were the result of combined tape and stadia surveys. The sheet and parcel numbering system used on these plans was later adapted for use on the general taking plans.

A paper entitled "Surveys for Swift River Reservoir of the Boston Metropolitan Water Supply" by N. LeRoy Hammond is included in Volume 96 of the Transactions of the American Society of Civil Engineers and is referred to for a comprehensive account of the methods chosen for surveying and mapping the Quabbin Reservoir area.

The field office was supplied with photostatic copies of deed abstracts as soon as the originals were available. These copies in negative were in reduced form, four sheets appearing on an 8½ by 11 in. sheet. The reduction did not affect the readability of the material, and as nearly 2,500 abstracts having from 10 to 50 and sometimes 100 sheets each were involved, a very considerable saving in expense was effected.

When each transaction reached the option stage, the Chief Engineer received notification from the Secretary and a report was obtained from the Division Engineer giving up-to-date information relative to the property. This information, referred to the Commission with copies for the Conveyancer, served as a final checking source before deeds were sent out for the grantor's signature. As settlements were completed, copies of deeds were received from the Conveyancer.

These provided the authority for indicating purchases progressively on general real estate maps. Such additions were shown in color and indicated progress by increase in color mass. Each week a report showing the progress of real estate purchases has been made. It has been based on area and has shown approximately the acreage purchased and that under consideration for purchase, and has provided information for use in all annual reports of the Commission.

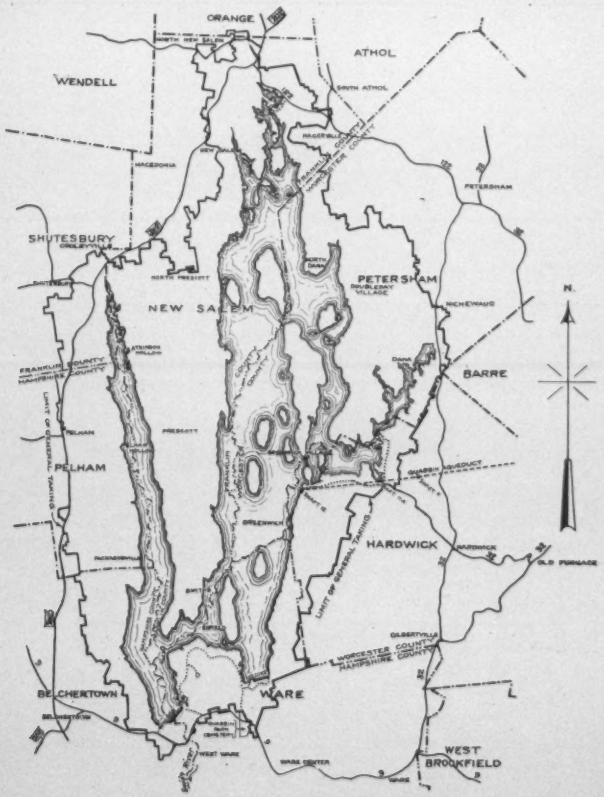


FIG. 8.—QUABBIN RESERVOIR, LIMIT OF GENERAL TAKING.

General Taking. On March 24, 1938, a taking was made covering 74,886 acres of land in the Quabbin Reservoir area (Fig. 8). This taking included land in 12 towns, located in Hampshire, Franklin and Worcester Counties. It was recorded and became effective on March 28, 1938, and thirty days later because of it, as previously noted, 4 established towns went out of existence as political units, and

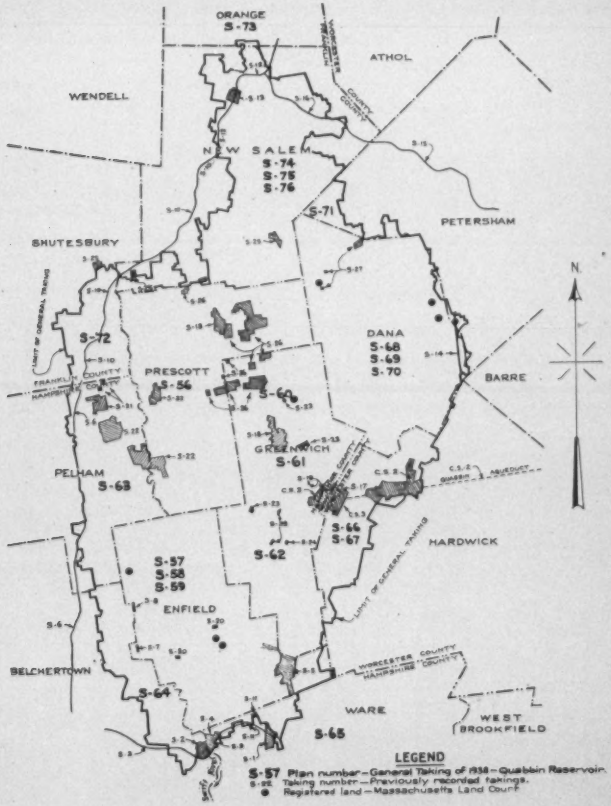


FIG. 9.—QUABBIN RESERVOIR, INDEX MAP.

TAKING RECORD

Taking No	Owner or Purpose	Town	County	Instrument Date	Recorded Book	Recorded Page	Plan No.	Plan Date	Plan Recorded Book	Plan Recorded Page
S-1	Quabbin Park Cemetery	Ware	Hampshire	June 11, 1931	872	523	S-1	June 11, 1931	14	5
S-2	Lekarczyk	Belchertown	Hampshire	July 17, 1931	873	426	S-7	July 17, 1931	14	70
S-3	Ware-Belchertown Hwy.	Ware / Belchertown	Hampshire	July 21, 1931	874	423	S-2-6	July 21, 1931	14	74-78
S-4	Szymanski	Ware	Hampshire	Aug. 19, 1932	882	532	S-8	Aug. 19, 1932	17	40
S-5	Wesson	Greenwich, Ware & Enfield	Hampshire	Nov. 5, 1932	884	452	S-9	Nov. 9, 1932	17	66
S-6	Daniel Shays Hwy.	Belchertown & Pelham	Hampshire	July 15, 1933	889	361	S-10-14	July 15, 1933	18	14-18
S-7	Vezina	Enfield	Hampshire	July 15, 1933	888	387	S-16	July 15, 1933	18	19
S-8	Chaffee	Enfield	Hampshire	July 27, 1933	889	491	S-15	July 27, 1933	18	21
S-9	Szymanski	Ware	Hampshire	July 27, 1933	889	492	S-17	July 27, 1933	18	22
S-10	Daniel Shays Hwy.	New Salem & Shutesbury	Franklin	Aug. 16, 1933	779	377	S-18	Aug. 18, 1933	10	32
							S-19	Aug. 18, 1933	10	33
							S-20	Aug. 18, 1933	10	36
							S-21	Aug. 18, 1933	10	37
							S-22	Aug. 18, 1933	10	40
							S-23	Aug. 18, 1933	10	41
S-11	Parker	Ware	Hampshire	Aug. 16, 1933	889	461	S-24	Aug. 16, 1933	18	24
S-12	Daniel Shays Hwy.	New Salem & Orange	Franklin	Nov. 17, 1933	797	81	S-25-27	Nov. 17, 1933	10	42-44
S-13	Aborn	New Salem & Orange	Franklin	May 26, 1934	805	42	S-28	May 26, 1934	10	52
S-14	Petersham-Hardwick Hwy.	Dana & Petersham	Worcester	May 8, 1936	2,666	215	S-29	May 8, 1936	91	12
S-15	New Salem-Petersham Hwy.	Petersham	Worcester	May 25, 1936	2,667	254	S-30	May 25, 1936	91	24
							S-31	May 25, 1936	91	71
							S-32	May 25, 1936	92	2
S-16	" " " "	New Salem	Franklin	July 13, 1936	818	2	S-33	July 13, 1936	11	2, 3
							S-34	July 13, 1936	11	4, 5
S-17	South Baffle	Hardwick / Greenwich	Worcester / Hampshire	July 29, 1936 / July 30, 1936	2,672 / 916	52 / 463	S-35	July 29, 1936 / July 31, 1936	91 / 20	64 / 37
S-18	Latham	Prescott & Greenwich	Hampshire	July 13, 1937	924	298	S-36, 37	July 13, 1937	21	13, 12
S-19	Moore	Hardwick / Greenwich	Worcester / Hampshire	Aug. 21, 1937 / Aug. 14, 1937	2,702 / 926	443 / 421	S-38	Aug. 21, 1937 / Aug. 14, 1937	97 / 21	15 / 20
S-20	Woodlawn Cemetery / Cemetery Hill & Church Cem.	Enfield	Hampshire	July 30, 1937	926	521	S-39	July 29, 1937	21	16
		Enfield	Hampshire	July 30, 1937	926	521	S-40	July 29, 1937	21	17
S-21	Whipple	Shutesbury / Pelham	Franklin / Hampshire	Feb. 2, 1938 / Jan. 21, 1938	826 / 930	53 / 481	S-41	Feb. 3, 1938 / Jan. 21, 1938	11 / 21	53 / 45
S-22	"	Pelham & Prescott	Hampshire	Jan. 21, 1938	930	483	S-42-45	Jan. 21, 1938	21	46, 47, 48, 44

TAKING RECORD (*Continued*)

Taking No.	Owner or Purpose	Town	County	Instrument Recorded Date	Book	Page	Plan No.	Plan Recorded Date	Book	Page
S-23	Lego	Greenwich	Hampshire	Aug. 21, 1937	926	461	S-46, 47	Aug. 25, 1937	21	26, 9
S-24	Greenwich Cem.	Greenwich	Hampshire	Oct. 6, 1937	927	521	S-53	Oct. 6, 1937	21	28
S-25	Powers	New Salem	Hampshire	Oct. 8, 1937	826	2	S-51	Oct. 8, 1937	11	46
		Shutesbury	Franklin	Oct. 8, 1937	826	2	S-52	Oct. 8, 1937	11	19
S-26	" & Harrington	Prescott & Greenwich	Franklin	Oct. 6, 1937	927	522	S-48, 49	Oct. 6, 1937	21	32, 29
S-27	"	Dana & Petersham	Hampshire	Oct. 6, 1937	2,705	501	S-50	Oct. 6, 1937	100	7
S-28	Anderson & Stratton	Greenwich	Worcester	Oct. 8, 1937	927	390	S-54, 55	Oct. 8, 1937	21	33
S-29	General Taking	Prescott	Hampshire	March 28, 1938	932	1	S-56	March 28, 1938	21	64
			Hampshire	March 28, 1938	932	1	S-57	March 28, 1938	21	57
S-29	" "	Enfield	Hampshire	March 28, 1938	932	1	S-58	March 28, 1938	21	58
			Hampshire	March 28, 1938	932	1	S-59	March 28, 1938	21	59
			Hampshire	March 28, 1938	932	1	S-60	March 28, 1938	21	60
S-29	" "	Greenwich	Hampshire	March 28, 1938	932	1	S-61	March 28, 1938	21	61
			Hampshire	March 28, 1938	932	1	S-62	March 28, 1938	21	62
S-29	" "	Pelham	Hampshire	March 28, 1938	932	1	S-63	March 28, 1938	21	63
S-29	" "	Belchertown	Hampshire	March 28, 1938	932	1	S-64	March 28, 1938	21	56
S-29	" "	Ware	Hampshire	March 28, 1938	932	1	S-65	March 28, 1938	21	65
S-29	" "	Hardwick	Hampshire	March 28, 1938	2,718	1	S-66, 67	March 28, 1938	103	3
S-29	" "	Dana	Worcester	March 28, 1938	2,718	1	S-68, 69, 70	March 28, 1938	103	4
S-29	" "	Petersham	Worcester	March 28, 1938	2,718	1	S-71	March 28, 1938	103	2
S-29	" "	Shutesbury	Worcester	March 28, 1938	829	1	S-72	March 28, 1938	11	72
S-29	" "	Orange	Franklin	March 28, 1938	829	1	S-73	March 28, 1938	11	73
			Franklin	March 28, 1938	829	1	S-74	March 28, 1938	11	74
S-29	" "	New Salem	Franklin	March 28, 1938	829	1	S-75	March 28, 1938	11	75
			Franklin	March 28, 1938	829	1	S-76	March 28, 1938	11	76
			Franklin				T-24	April 1, 1931	66	57
C.S.-2	Coldbrook-Swift Tunnel	Hardwick		April 1, 1931	2,539	201	T-25	April 1, 1931	66	61
			Worcester				T-26	April 1, 1931	67	2
C.S.-3	" " "	Hardwick		April 1, 1931	2,539	181	T-27	April 1, 1931	66	3
	" " "	Greenwich	Worcester	April 2, 1931	871	536	T-27	April 2, 1931	13	72

NOTE:—Plans showing detailed information on a scale of 1 inch = 200 ft. of all properties included in these takings are on file at the offices of the Metropolitan District Water Supply Commission.

Vol. 19

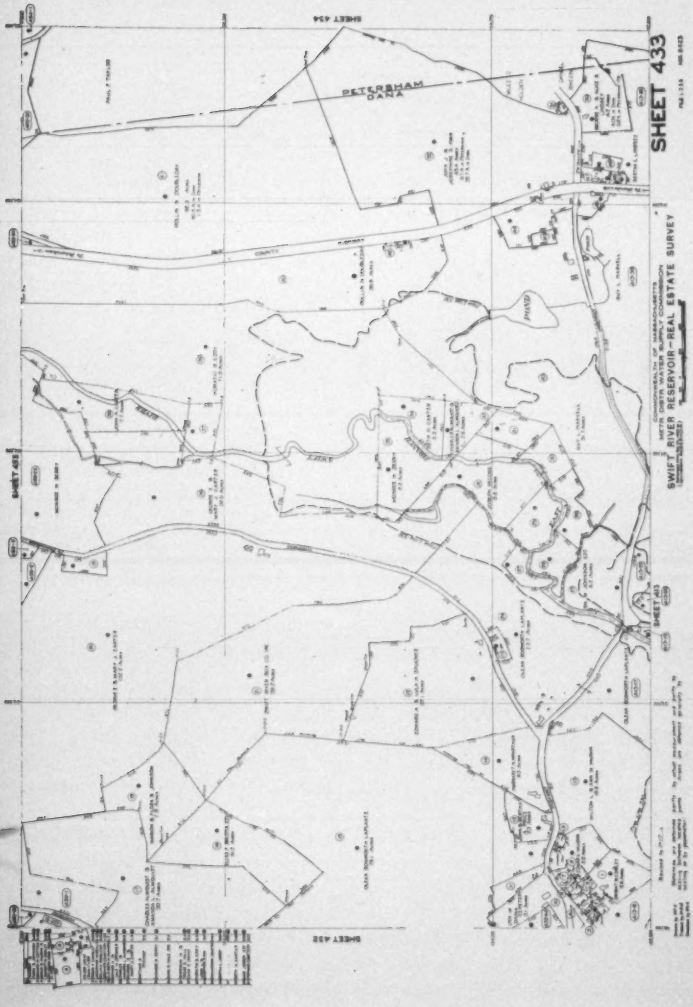
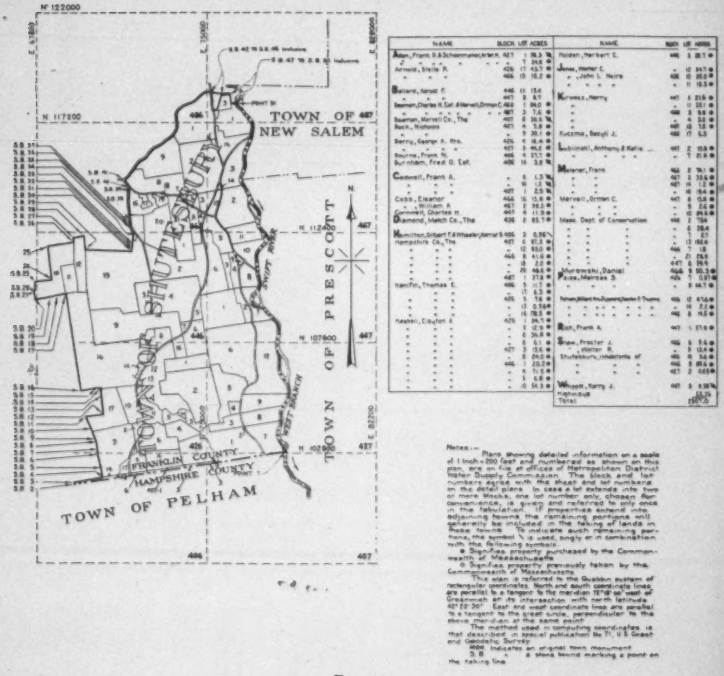

SHEET 433
SWIFT RIVER RESERVOIR—REAL ESTATE SURVEY
PETERSHAM
DANA
SHEET 434
SHEET 432
SHEET 433

FIG. 10.


TOWN OF NEW SALEM
TOWN OF PRESCOTT
TOWN OF SHUTESBURY
TOWN OF PELHAM
FRANKLIN COUNTY
HAMPSHIRE COUNTY
Main St.
West Branch
West Branch
N 122000
N 117200
N 112400
N 107600
N 102800
E 92000
E 96800
E 101600
E 106400
E 111200
E 116000
E 120800
E 125600
E 130400
E 135200
E 140000
E 144800
E 149600
E 154400
E 159200
E 164000
E 168800
E 173600
E 178400
E 183200
E

DESCRIPTION—EXTERIOR LINES OF TAKING

Corner	Bearing	Abutter	Distance (Feet)
Point 1	S 80° 40′ 50″ W	Town of Pelham	9,118.65
S.B. 2	N 18° 51′ 54″ W	Charles H. Jones	98.37
S.B. 3	N 80° 40′ 36″ E	Alfred H. Frost & Charles H. Davis	1,253.98
S.B. 4	N 08° 01′ 23″ W	Alfred H. Frost & Charles H. Davis	405.32
S.B. 5	N 13° 55′ 03″ W	Alfred H. Frost & Charles H. Davis	660.60
S.B. 6	N 01° 58′ 29″ W	Alfred H. Frost & Charles H. Davis	180.22
S.B. 7	N 07° 29′ 15″ W	Alfred H. Frost & Charles H. Davis	345.25
S.B. 8	N 26° 53′ 33″ W	Alfred H. Frost & Charles H. Davis	130.64
S.B. 9	N 20° 14′ 32″ W	Alfred H. Frost & Charles H. Davis	498.83
S.B. 10	N 28° 27′ 24″ W	Alfred H. Frost & Charles H. Davis	575.12
S.B. 11	N 81° 07′ 16″ E	Alfred H. Frost & Charles H. Davis	795.15
S.B. 12	N 06° 57′ 39″ W	Alfred H. Frost & Charles H. Davis	791.65
S.B. 13	N 06° 11′ 10″ W	Alfred H. Frost & Charles H. Davis	360.62
S.B. 14	N 87° 46′ 05″ W	Alfred H. Frost & Charles H. Davis	165.62
S.B. 15	S 78° 23′ 48″ W	Alfred H. Frost & Charles H. Davis	701.81
S.B. 16	N 08° 48′ 36″ W	Charles H. Beaman, Estate Jos. H. Howard & Walter D. Cowls, Hrs. Amy F. Ryder	4,282.60
S.B. 17	S 85° 07′ 43″ W	Amy F. Ryder	288.16
S.B. 18	S 72° 03′ 05″ W	Amy F. Ryder	288.35
S.B. 19	S 79° 38′ 14″ W	Amy F. Ryder	718.81
S.B. 20	N 04° 15′ 01″ W	Miner E. & Clarence E. Haskell	380.76
S.B. 21	N 74° 48′ 08″ E	Miner E. & Clarence E. Haskell	44.63
S.B. 22	N 02° 07′ 26″ W	Miner E. & Clarence E. Haskell	378.55
S.B. 23	N 82° 09′ 58″ E	Walter C. Jones	673.74
S.B. 24	N 07° 39′ 17″ W	Walter C. Jones	1,450.89
S.B. 25	N 78° 53′ 43″ E	Clayton A. Haskell, Angenora Jepson	1,126.56
S.B. 26	N 06° 36′ 25″ W	Angenora Jepson	135.24
S.B. 27	N 78° 53′ 50″ E	Clayton A. Haskell	469.76
S.B. 28	S 08° 29′ 59″ E	John Rehorka	588.68
S.B. 29	S 88° 46′ 23″ E	John Rehorka	1,948.60
S.B. 30	N 08° 41′ 48″ E	West side Old Town Road	73.94
S.B. 31	N 17° 03′ 43″ E	West side Old Town Road	107.70
S.B. 32	N 04° 01′ 04″ W	West side Old Town Road	125.03
S.B. 33	N 07° 18′ 11″ E	West side Old Town Road	374.77
S.B. 34	N 24° 03′ 23″ W	West side Old Town Road	308.86
S.B. 35	N 00° 34′ 45″ W	West side Old Town Road	100.25
S.B. 36	N 14° 13′ 06″ E	West side of Old Town Road	43.48
S.B. 37	Easterly	Across Old Town Road from Pelham to Shutesbury	40.00
S.B. 38	Northerly	On East side of said road to West side of road from Prescott to Shutesbury	1,730 ±
S.B. 39	Northeasterly	Across Prescott-Shutesbury Rd.	40
S.B. 40	Northerly	On East side of said road to East side of road from Cooleyville to Shutesbury	285 ±
S.B. 41	Northeasterly	On East side of Cooleyville-Shutesbury Road to west side of road from Prescott to Wendell	5,850 ±
S.B. 42	Southerly	On West side of said road	770 ±
S.B. 43	N 88° 07′ 32″ E	Across Cooleyville-Shutesbury Road	33.00
S.B. 44	N 88° 07′ 32″ E	Charles E. Pratt	148.64
S.B. 45	N 16° 46′ 37″ E	Charles E. Pratt	715.72
S.B. 46	Easterly	Along south side of Cooleyville-Shutesbury road	360 ±
S.B. 47	S 07° 47′ 14″ E	Chares F. Frost	402.52
S.B. 48	N 76° 33′ 44″ E	Charles F. Frost	262.45
S.B. 49	S 63° 14′ 20″ E	Charles F. Frost	9.15
S.B. 50	S 63° 14′ 20″ E	Charles F. Frost	31 ±
Point 51	Southerly	Along thread of West Branch of Swift River to point of beginning	19,070 ±
Point 1			

ownership was listed in alphabetical order, each parcel being identified by parcel number and acreage. If old methods requiring the description of all individual parcels had been continued, a total of 210 plans would have been required with a corresponding increase in legal work.

Taking plans of a size 18 by 27 in. to agree with the requirements of Hampshire County, which were acceptable to the other two counties, were prepared on a scale of 1 in. = 2,000 ft. For detailed information, reference was made to the regular real estate survey sheets, scale 1 in. = 200 ft., on file at offices of the Commission. The parcel designations, being identical, serve as a rapid cross index. Enlargements of villages and tabulations of descriptive matter were given when required for clarity. An alphabetical list of owners, "keyed" to the parcel-numbering system, was given in every case. This name list indicated by symbol the status of ownership just before the taking date, and became for the purpose of the taking document, a direct guide. Examples of taking plans are shown in Figs. 8 to 11.

Prior takings of lands which had been made for construction requirements, if within the limits of the general taking, were again taken without comment in the legal document. Such previous takings were, however, indicated by symbol on the taking plans. Registered lands were listed separately and identified by Land Court Case and Certificate number.

The scale of these plans rendered it impossible to give descriptive information in the usual manner, that is along the lines defined. To overcome this obstacle, a table entitled, "Description—Exterior lines of taking," was made a part of the plan, referring directly to each corner of the boundary and giving bearing and distance of line, and abutting ownership.

The names appearing in the tabulation were presented in a consistent manner in accordance with instructions of the Chief Engineer issued November 3, 1937, which are quoted in part as follows:

"The following instructions are to be used when determining the name of original owner, for entry in our various records and plans and for use in the final taking.

1. The authority for name adopted is found in the sources named below:
   a. Introductory clause of deed.
   b. Grantor's signature, if differing from (a).
   c. Meaning and intending clause of deed, if collective ownerships, such as heirs or associations are named.

   Ordinarily use first name and middle initial.

2. When two names are given, use both.
3. When three or more names are given, use a principal name and the term *et al.;* example, John F. Jones *et al.*
4. When husband and wife join in the the transfer as "tenants in common", "tenants by the entirety" or "joint tenants", name both husband and wife; example, John J. and Mary S. Jones.
5. Do not name the husband or wife who had dower rights only. Name only the person who acquired title.
6. When husband and wife are both named, but the phrase "in his (or her) own right" is used, adopt the name of the person holding the right.
7. In the following examples of estate and other names, the first column will be considered primary and is to appear on taking plans, and will generally be used on all forms and records. The second column will be considered secondary information and will appear on other records for cross reference purposes.

a. Charles D. Smith Estate	John J. Jones, Adm., Exec. etc.
b. Charles D. Smith Heirs (in case of sole heir, use name of heir)	John J. Jones, *et al.*
c. Charles D. Smith, Trustee	John J. Jones
d. Charles D. Smith	John J. Jones Gdn. or Cons.
e. Swift River Box Co.	Frank S. Grover & Charles E. Gee
f. Massachusetts Congregational and Missionary Society	Enfield Congregational Church.

For devising this method of identifying property, credit should go to C. Ridgely Brown, a member of the engineering force and connected with its real estate section since the beginning of the work. Exceptions arise occasionally, but for the great majority of cases this method provides a consistent guide for filing purposes. Its use begins when the deed to the Commonwealth is at hand, and at that time former identifications are revised.

Real Estate Costs

On May 31, 1939, the Metropolitan District Water Supply Commission had acquired 90,185 acres of land with the buildings thereon in the Swift River and Ware River watersheds including the necessary rights-of-way for tunnel, highway and trunk sewer purposes, at a total cost of $9,587,198 or at the rate of $106.31 per acre.

This cost is itemized and distributed as shown in Tables 3 and 4.

The first tabulation gives total costs of purchases and settlements, direct and indirect overhead charges, deductable revenues, and finally unit costs per acre based on purchases and settlements and based on

TABLE 3.—REAL ESTATE COSTS TO MAY 31, 1939

Section	Purchases & Settlements[a]	Direct Overhead[b]	Indirect Overhead[c]	Gross Cost	Revenues Sales & Rents	Net Cost	Unit Cost per Acre Purch. & Settle.	Unit Cost Based on Net Cost
Swift River Watershed including Quabbin Park Cemetery (74,404 acres)	$8,065,963	$ 983,270	$403,044[d]	$ 9,452,277	$927,700	$ 8,524,577	$108.41	$114.57
Ware River Watershed including Rutland-Holden Sewer (14,710 acres)	1,371,628	312,055	42,210* part f	1,725,893	30,000	1,695,893	93.24	115.29
Quabbin Aqueduct (1071 acres)	149,607	49,417	4,690*	203,714	10,000	193,714	139.69	180.87
Total Project (90,185 acres)	9,587,198	1,344,742	449,944[d, e, and f]	11,381,884	967.700	10,414,184	106.31	115.48
Coldbrook-Swift Section of Quabbin Aqueduct (518 ac.)	26,260	9,941	719*	36,920	None	36,920	50.69	71.27
Wachusett-Coldbrook Section of Quabbin Aqueduct (553 acres)	123,347	39,476	3,971[part f]	166,794	10,000	156,794	223.05	283.53
Swift River Watershed and Quabbin Aqueduct (75,475 acres)	8,215,570	1,032,687	407,734[d, e, part f]	9,655,991	937,700	8,718,291	108.85	115.51
Ware River Watershed and Wachusett-Coldbrook Section (15,263 acres)	1,494,975	351,531	46,181	1,892,687	40,000	1,852,687	97.95	121.38

[a]Includes awards by Court Decree-Jury and Board of Referees.
[b]Includes legal, expert and trial expense, taxes, maintenance, fire and police protection, rental expense, etc.
[c]Includes percentage of field engineering and general overhead charges as noted by d, e and f.
[d]49% of total general overhead and engineering charges.
[e]0.5% of total general overhead and engineering charges.
[f]10.8% of total general overhead and engineering charges.
*Estimated proportion of $46,900.

TABLE 4—DISTRIBUTION OF REAL ESTATE COSTS IN ACCORDANCE WITH LAND USE

Type of Property	Area Acres	Purchases and Settlements	Overhead *Less Revenues* 5.68% of Purchases and Settlements	Total Net Cost	Unit Cost Per Acre Based on Settlements Only	Unit Cost Per Acre Based on All Costs	Average Lot Acres	Number of Examples
			Swift River Watershed—Quabbin Reservoir and Vicinity					
Residential	45.89	$153,125	$ 8,697.50	$161,822.50	3,336.78	3,526.31	1.09	42
Farm[a]	4,869.15	392,700	22,305.36	415,005.36	80.65	85.23	66.71	73
Woodland[b]	1,245.84	34,496	1,959.37	36,455.37	27.69	28.35	36.6	34
Recreational	131.16	80,075	4,548.26	84,623.26	610.51	645.19	5.7	23
			Ware River Watershed—Above Coldbrook 23.64% Pur. & Set.					
Residential	17.84	52,100	12,316.44	64,416.44	2,920.40	3,610.79	1.27	14
Farm[a]	1,855.38	69,400	16,406.16	85,806.16	37.40	46.25	116.0	16
Woodland[b]	696.02	10 454	2,471.33	12,925.33	15.02	18.57	38.66	18
Recreational	103.52	32,625	7,712.55	40,337.55	315.16	389.66	6.6	16

[a]Tillable land, pasture and woodland with buildings.
[b]Not connected with farm property.

net cost. It covers various sections of the work for purposes of comparison with other work of similar characteristics. Table 4 shows the distribution of real estate costs in accordance with land use. Four types of property are considered, residential, farm, woodland and recreational. Properties of a business or industrial nature were so diversified that comparisons were not possible and are, therefore, not included. Approximately 10 per cent of the settlements in the Swift River watershed and 33 per cent of the settlements in the Ware River watershed were chosen at random for the purposes of this table.

In Tables 3 and 4, the unit price per acre based on the item "purchases and settlements" is the most suitable standard for comparison of costs. A number of variable causes affect the total cost columns, rendering them less precise. Among these causes are: overhead charges, both direct and indirect, which are still accumulating; accounting methods as to choice of items which are to be charged against real estate; unusual conditions which occur in one section and not in others, for example town liquidation costs and town administration costs in the Swift River watershed only. Approximately 93 per cent of the required settlements in the Swift River and 78 per cent of those in the Ware River watershed have been completed. Most of the costly business and industrial properties have been acquired, and it is assumed that the final unit cost figures will be somewhat less than the ones given in this report.

The relation between assessed value and price paid for the real estate considered in Table 4 has been determined, and while it only reflects the practice of the assessing bodies in a limited territory and has no definite value as a basis for comparison with other localities, it is given as a matter of interest. For the selected properties in the Quabbin Reservoir and adjoining areas assessments amounted to 38 per cent of the purchase price. This was slightly more in the Ware River watershed where it amounted to 44 per cent.

Another matter of interest is the relation between the original offer by the seller and the price paid to him. In the properties considered in Table 4 it was found that in the Quabbin Reservoir region, the price paid was 64 per cent of the offer. In the Ware River watershed the percentage was 88 per cent.

The facts gathered for the preparation of Table 4 included information capable of further extension, and for the Swift River watershed Table 5 has been prepared showing approximate cost of buildings

TABLE 5—COST OF BUILDINGS AND LAND, SWIFT RIVER WATERSHED

Type of Property	Cost Based on Settlements				Cost Range Per Acre	
	Buildings Per Unit	Land Per Acre	Classification Tillage	Woodland	Tillage	Woodland
Residential	$3,645	$309	—	—	$50 to $1433	—
Farm	4,609	31.43	29%	71%	$15 to $156	$6 to $227
Woodland	—	27.68	—	—	—	$7 to $136
Recreational general	2,841	135	—	—	$17 to $2,610	
Camp	2,395	769	—	—	$20 to $2,610	
Summer Cottage	3,685	96	—	—	$17 to $1,330	

and of land without buildings, and in the case of farmland, the percentage of tillage and woodland.

It is possible to give an interesting comparison of the "sampling" method used in the case of farm property, because in July, 1928, an examination was made of 30 parcels picked at random in order to learn the approximate cost of tillage and woodland. At that time the value of such land was given as $32.75 per acre, comparing with $31.43 per acre. Tillage land was 31% of the total compared with 29% determined in the more recent examination with a corresponding agreement respecting woodland.

The Commission has acquired other properties of varied natures, examples of which are:

SWIFT RIVER WATERSHED

Business Properties	2 large camps accommodating 290 boys	
	1 large camp accommodating 156 girls	
	1 small camp accommodating 12 girls	
	Swift River Hotel	Enfield
	Harvey's Inn	Dana
	Kennedy's Hotel	Dana
	Wayside Stand	Dana
	Coal and grain	Enfield
	Coal and grain	Dana
	Natural Ice Storage	Greenwich—14,000 tons
	Carpenter	Dana
	Garage	Enfield
	Blacksmith	Enfield
	Stores—Enfield, Dana	Greenwich

WARE RIVER WATERSHED

	Stores	Rutland and Oakham
	Garage	Rutland

	Garage	Oakham
	2 Filling Stations	Oakham
	Tourist	Oakham
	Swift River Watershed	
Industrial Properties	2 Hat Shops	Dana
	Textile Plant	Dana
	2 Textile Plants	Enfield
	Saw Mill	Greenwich
	Grist Mill	Greenwich
	Ware River Watershed	
Industrial Properties	Duck Products	
	Woolens	
	Wool Worsted	
	Shoddy	
	Wooden Chairs	
	Lumber Mill	
	Nails	

Miscellaneous Private School—Hillside School
Summer Camps—Y.W.C.A. of Holyoke
Girls Club of Springfield
Boy Scouts of Fitchburg
Private Water Supplies—Griffin-Hall, Greenwich
Quabbin Aqueduct Co., Enfield
Telephone Service—Highland Telephone Co.
Railroad Right-of-way—Boston and Albany R.R.
Golf Course—Mahar and Duggan
Church Properties— 1 in Ware River Watershed
11 in Swift River Watershed

Cemeteries	public	12	association	3
	family	12	neighborhood	7

The railroad right-of-way, extending through the length of the Quabbin Reservoir for 20.43 miles, cost $641,240 at the rate of $31,827 per mile. About 190 acres, $3,375 per acre. Buildings were included in the agreement. Track and pole lines were salvaged by the railroad. This railroad branch ceased operations on June 1, 1935.

In 1933 the Commission arranged with the New Enland Power Company and the Central Massachusetts Electric Company for the removal and relocation of transmission lines which entered the Quabbin Reservoir area. The 66,000-volt Shelburne Falls-Millbury line was temporarily discontinued and moved to the west, using the old towers and other equipment at the new location.

TABLE 6.—HIGHWAY PURCHASES—BEYOND GENERAL TAKING
Summary

Taking No.	Highway	Full Width (80 ft.) Taking Lin. Ft.	Acres	Cost	Strip Taking Lin. Ft.	Acres	Cost	Total Taking Lin. Ft.	Acres	Cost
S-3	Ware-Belchertown	8,780	15.88	$ 9,890	3,957	2.38	$ 1,800	12,737	18.26	$11,690
S-6	Daniel Shays	8,950	15.73	8,650	11,604	10.97	8,100	20,554	26.70	16,750
S-10	Daniel Shays	15,800	29.57	7,350	1,200	1.07	530	17,000	30.64	7,880
S-12	Daniel Shays	1,550	2.80	350	2,850	3.36	2,355	4,400	6.16	2,705
S-15	New Salem-Petersham	3,350	6.57	2,050	1,543	1.79	1,460	4,893	8.36	3,510
S-16	New Salem-Petersham	1,950	4.02	200	1,550	0.87	600	3,500	4.89	800
		40,380	74.57	$28,490	22,704	20.44	$14,845	63,084	95.01	$43,335

The golf course of 9 holes, covering 161.5 acres and including an up-to-date club house, cost $179,042, $1,108 per acre, and incidentally $19,893 per hole. This settlement was made by order of the Board of Referees. The original verdict returned on January 25, 1934, amounted to $221,000. The Commission appealed and on July 28, 1937, a second finding was returned in the amount of $150,000. Interest charges brought the total cost up to the amount of $179,042. The original claim by the owners was $400,000 and the maximum damage estimates of the Commission's engineers amounted to $57,000.

Practically 1/3 of the new highway construction was through lands not taken for general reservoir purposes and its cost is therefore determinable. The cost, divided for purposes of comparison, into full width, strip and total takings, is shown in Table 6.

Full width takings through 7.6 miles of new location cost about $3,750 per mile or $315 per acre. Narrow strips taken along 4.3 miles of existing highway cost about $3,450 per mile or $726 per acre. The total unit cost, including both types of taking amounted to $3,640 per mile or $456 per acre.

Settlements for the Rutland-Holden Sewer should not exceed $35,000. This will amount to about $3,685 per mile. Based on the total area of about 23 acres remaining under Commonwealth ownership after construction easements have terminated, the unit cost per acre is about $1,520.

The church properties represented a total outlay of $159,500 for church edifices, parsonages and land, an average of $13,292 per unit. Public cemeteries have been acquired by the process of securing releases from individual owners when possible and in addition by the general taking of March 28, 1938. Private cemeteries have been acquired through purchase of the land of which they were a part.

On May 31, 1939, $44,457,153 had been spent for the Quabbin Reservoir and its associated projects. Expenditures for real estate for the same period had reached to $10,414,184 or about 24 per cent of the entire cost. This percentage seems at first glance to be high and the opinion may be formed that payments for real estate have been high. This is not actually the case, and in the comparisons with well-known water supply projects given in Tables 7 and 8 it will be shown that unit prices per acre for real estate have been generally lower than elsewhere and that the total real estate cost is high because of extensive purchases for watershed protection.

FIG. 12.—MILLINGTON DAM.

None of the factors involved in these comparisons is controllable; therefore, the old saying that "comparisons are odious" may hold true, but they are nevertheless offered with the advance reservation that no compensation has been attempted for periods of wars to end wars, booms or depressions; distance from centers of population; or any other cause, natural or artificial.

Two tables (7 and 8) are given, the first relating to costs only. A startling item included in this table is the high percentage of expense noted in connection with the Catskill supply for New York City. The influences responsible for the additional costs were explained in an article by Frank E. Winsor published in the Journal of the Boston Society of Civil Engineers,[5] as a part of the discussion of a paper by Henry F. Bryant "Duties of the Engineer in Connection with Land Takings: State and Municipal Projects." Mr. Winsor's figures were taken from the annual report of the Board of Water Supply of the City of New York for the calendar year 1927.

Table 8 shows that the marginal lands acquired for the protection of Quabbin Reservoir in the Swift River watershed are about 51 per cent greater than the average for the reservoirs compared. With the addition of the Ware River watershed which is available for the benefit of Quabbin Reservoir, the excess becomes about 86 per cent.

[5]Vol. 15, October 1928.

TABLE 7.—COST COMPARISONS OF REAL ESTATE FOR WATER SUPPLY RESERVOIRS

Reservoir	Area in Acres	Purchases and Settlements	Unit Cost P & S Per Acre	Expense	Expense Per Acre	Capacity Million Gallons	Pur. & Set. Per Mil. Gal. of Capacity
New York							
Catskill[a]	23,800	$11,524,896	$484.24	$6,997,065	$293.99	177,000	$ 65.11
Ohio							
O'Shaughnessy[b]	1,156	290,130	250.98	No information available		5,341	54.32
Rhode Island							
Scituate[c]	14,660	4,100,000	279.67	550,000	37.52	37,000	110.81
Massachusetts							
Wachusett[d]	7,885	2,949,437	374.06	232,193	29.45	64,968	45.40
Quabbin	74,404	8,065,963	108.41	458,614	6.16	405,000	19.92
Swift-Ware Watershed (Does not include connecting tunnel)	89,114	9,437,591	105.90	782,879	8.79	405,000	23.30

[a]Frank E. Winsor—Journal B.S.C.E. 15, Oct. 1928.
[b]The O'Shaughnessy Dam & Reservoir—John H. Gregory, C. B. Hoover, & C. B. Cornell, Trans. Am. Soc. C. E. 93, 428 *et seq.*
[c]Providence, R. I. Water Supply Damage Settlements—Earl C. Craig—Journal N.E.W.W.A. 40, 503.
[d]Financial Report—Metr. Water & Sewerage Board—Jan. 1, 1906, p. 13.

TABLE 8.—AREA COMPARISONS OF REAL ESTATE ACQUIRED FOR WATER SUPPLY RESERVOIRS

Reservoir	Reservoir Area Acres	Land Acquired Acres	Watershed Area Acres	Ratio of land acquired to reservoir	Ratio of watershed to reservoir	Ratio of watershed to land acquired
New York						
Ashokan	8,180	15,222	164,480	1.86[a]	20.11	10.80
Kensico	2,218	4,500	14,080	2.03[a]	6.35	3.13
Scoharie	1,145	2,372	200,960	2.07[a]	175.51	84.72
Rhode Island						
Scituate	3,600	12,547	59,392[b]	3.49[a]	16.41	4.74
Ohio						
O'Shaughnessy	829	1,159	632,320	1.40[a]	762.75	545.57
Massachusetts						
Wachusett	4,135[c]	7,885	74,905[d]	1.91	18.11	9.49
Total	20,107	43,685	1,146,137	2.17	57.00	26.23
Quabbin	24,704	81,000[e]	119,040	3.28	4.83	1.47
Quabbin incl. Upper Ware Watershed	24,704	100,000[e]	180,992	4.05	7.33	1.81

[a]Dittoe and Dixon—Discussion, O'Shaughnessy Dam and Reservoir, Trans. A.S.C.E. **93**, 1497.
[b]Frank E. Winsor—The New Water Supply of the City of Providence, Jour. N.E.W.W.A. **36**, 323.
[c]Estimated final requirements.
[d]Mass. House Document No. 262, 1937—Table 12, Water Supply Improvement.
[e]Metr. Distr. Comm. Miscellaneous Information, 1936, Table 5.

TAXATION

The Commonwealth of Massachusetts, while accumulating these extensive land holdings, also obligated itself to assume tax payments to the towns in which the lands were located. Section 20 of Chapter 321, Acts of 1927, which contained the legislation governing such payments is briefly summarized as follows:

Sections 6 and 7 of Chapter 59 of the General Laws became applicable to land acquired in fee by the Commission, with certain exceptions. This law required the Commission to pay the regular taxation on properties from which they received a rental income, and required in the case of non-income producing property, a payment in lieu of taxes based upon the value of land alone, for the three year period preceding purchase of the property. The exceptions concerned the towns of Enfield, Greenwich and Prescott, and provided for payments in lieu of taxes, based on a three year valuation including valuation of

TABLE 9.—AMOUNTS PAID IN LIEU OF TAXES AND FOR TAXES—QUABBIN RESERVOIR AREA AND WARE RIVER WATERSHED AREA

Yearly Totals		Details for Year 1938				
Year	Total Tax	Town	Valuation Basis	Rate	Amounts Paid	Total
1927	$ 1,764.51	Barre	$61,623.32 in lieu	$34.00	$ 2,095.19	$2,237.14
			4,175.00 tax		141.95	
1928[a]	11,574.75	Belchertown	20,475.00 in lieu	48.00	982.80	2,026.80
			21,750.00 tax		1,044.00	
1929	20,697.61	Hardwick	41,831.00 in lieu	44.00	1,840.56	2,452.16
			13,900.00 tax		611.60	
1930	29,625.49	Holden	4,953.00 in lieu	35.00	173.36	173.36
1931	39,204.50	Hubbardston	58,864.33 in lieu[c]	42.50	2,166.21[c]	2,366.77[c]
			5,450.00 tax[c]		200.56[c]	
1932	42,838.83	New Salem	175,014.55 in lieu	42.80	7,490.62	9,862.17
			55,410.00 tax		2,371.55	
1933	49,301.11	Oakham	24,860.00 in lieu	28.00	696.08	960.26
			9,435.00 tax		264.18	
1934	60,750.49	Pelham	60,372.00 in lieu	25.00	1,509.30	1,965.73
			18,257.00 tax		456.43	
1935	53,131.72	Petersham	16,925.00 in lieu	20.50	346.96	527.87
			8,825.00 tax		180.91	
1936	55,010.38	Princeton	8,605.00 in lieu	33.80	290.85	290.85
1937	62,743.07	Rutland	96,954.32 in lieu	25.90	2,511.12	2,835.13
			12,510.00 tax		324.01	
1938[b]	27,888.01	Shutesbury	63,116.00 in lieu	28.00	1,767.25	1,767.25
		Ware	8,010.00 in lieu	42.00	336.42	422.52
			2,050.00 tax		86.10	
						$27,888.01

[a]Prescott omitted 1928 and all following years.
[b]Dana, Enfield, and Greenwich omitted.
[c]1937 Amounts, 1938 not available for Hubbardston.

buildings. Such payments were continued until the towns ceased to perform as governmental units, as in the case of Prescott, or until annexation to other towns. For the loss of all revenue, tax or otherwise, due to the loss of these towns, the county of Hampshire was compensated $55,000.

Purchases in the town of Dana were so extensive that its annexation to the town of Petersham was considered advisable, and was authorized by Section 9, Chapter 240, Acts of 1938. This act provided that no further tax payments were to be made for property in Dana, Enfield, Greenwich and Prescott after their annexation to other towns.

Table 9 lists the payments made from 1927 through 1938 and gives the details of the 1938 payments.

Cemetery Removals from the Swift River Watershed

Thirty-four cemeteries located within the watershed have been abolished and nearly all remains contained therein have been removed to Quabbin Park Cemetery, established in 1932, or to other cemeteries located beyond the watershed. Of these 34 cemeteries, 13 were located within the limits of Quabbin Reservoir. A total of approximately 7,100 bodies will be removed from these old cemeteries, the smallest of which, 3 old family cemeteries, contained one body each, and the largest, Greenwich Cemetery, a public burial place, contained 1,680 bodies.

Burials in these cemeteries were prohibited by the Commission, acting in accordance with the provision of Section 5, Chapter 321, Acts of 1927, of the Commonwealth, by a notice to the towns of Belchertown, Dana, Enfield, Greenwich, Prescott and Shutesbury, given on August 25, 1932.

Removal work was performed under direct authority of the Commission after its consideration of each individual request. No removals were made without first giving some representative interested in the remains an opportunity to be present. See Figs. 13 and 14.

In the work of removal, excavations were carefully made. As most burials were made many years ago, the general condition presented was a complete disintegration of the coffin, clothing and physical frame. The skull and principal parts of the skeleton were usually intact. The entire remains were collected in wooden boxes, great care being used to discover and save every remaining element of the skeletal structure. This was then mixed with soil from its immediate vicinity and the box closed. The box was marked in agreement with surface

TABLE 10.—DISCONTINUED CEMETERIES IN VICINITY OF QUABBIN RESERVOIR

Cemetery	Location Original Town		Classification	Lots No.	Approx. No. Burials	Original Amounts Perpetual Care Funds	Area Acres
Bacon	Belchertown		Family	1	3	—	0.06
Blue Meadow	Belchertown		Neighborhood	1	15	—	0.20
Brown's	Dana	(1)	Family	32	100	$ 350	1.30
Brown's Evergreen	Dana	(1)	Family	14	65	—	0.36
*Cemetery Hill	Enfield	(2)	Association	59	254	2,225	1.29
*Church	Enfield	(2)	Public	238	853	1,850	1.39
Dana Center	Dana	(1)	Public	183	562	3,150	2.30
*Demars, Frank	Dana	(1)	Family	1	1	—	0.01
Fish Hill	Prescott	(2)	Public	71	175	175	0.9
Golden Lake	New Salem		Public	31	177	600	0.52
*Greenwich	Greenwich	(1)	Public	501	1,680	3,832.65	4.00
Hamilton	Shutesbury		Family	6	9	—	0.05
Hopkins	Dana	(1)	Neighborhood	9	28	—	0.10
Howe	Enfield	(2)	Family	1	18	—	0.40
*Linzie, Isaac	Prescott	(2)	Neighborhood	24	59	—	0.15
*Loomis	Dana	(1)	Family	1	1	—	0.01
*Ludlow Mfgs. Assn.	Enfield	(4)	Family	1	1	—	0.01
Mann, Thomas S.[a]	Prescott	(2)	Family	1	8	—	0.01

(*continued*)

Cemetery	Location Original Town		Classification	Lots No.	Approx. No. Burials	Original Amounts Perpetual Care Funds	Area Acres
*Old North Dana	Dana	(1)	Neighborhood	19	41	—	0.40
Packardsville	Enfield	(4)	Public	80	198	300	0.43
Packardsville Church	Enfield	(4)	Church Assoc.	7	22	—	0.06
*Pelham Hollow	Prescott	(2)	Public	189	738	300	1.6
*Pine Grove	Dana	(1)	Public	242	574	2,230	4.6
Pine Grove	Prescott	(2)	Association	90	166	917.52	1.3
*Powers, Jason	Prescott	(2)	Public	22	51	—	0.3
Richardson	Dana	(1)	Neighborhood	6	18	—	0.44
Shaker	Petersham		Family	1	3	—	0.07
Snow	Petersham		Public	20	45	100	1.4
Stone	Dana	(1)	Neighborhood	13	21	—	0.32
*Town	Dana	(1)	Family	8	21	—	0.26
Town House	Prescott	(2)	Public	60	206	450	0.71
Wilder	Enfield	(2)	Family	1	2	—	0.01
Williams	Dana	(1)	Neighborhood	17	41	—	0.11
*Woodlawn	Enfield	(2)	Public	370	949	1,825	3.68
				2,370	7,114	18,305.17	28.39

*Bellow flow line of Quabbin Reservoir.
*Sometimes called Brown's Cemetery.
(1) Now Petersham. (2) Now New Salem. (3) Now Ware. (4) Now Pelham.

FIG. 13.—CHURCH CEMETERY, ENFIELD.

evidence of markers, which was often confirmed by subsurface evidence of coffin plates. A thorough excavation of each lot was made and often the presence of other unrecorded burials was discovered by prodding the surface. Apparently, excavations of many years standing cannot be disguised except at the surface. When removals from each lot were complete, the remains, markers and monuments were transferred to prepared positions in the new location, and a careful record of the disposition was made.

All work was performed by a selected labor force of the Commission at regular labor rates under the supervision of the engineering department. Every effort was made to learn the status of ownership of lots in all the cemeteries subject to removal. This was not entirely possible, due to the dispersion of the families of the people who once populated the Swift River Valley. The Commission provided for these unrepresented, and in many cases unknown, bodies, by setting apart a portion of Quabbin Park Cemetery for their interment. A careful record of the original grave and present grave has been made, and every clue regarding the identity of the body has been preserved, pending the appearance of a claimant. Releases will probably be required from such claimants for the purpose of complete records. These are not, however, needed to assure title to the land, as this has been obtained by the general taking of March 28, 1938.

A few removals were, at the request of the relatives, made to cemetries in bordering states. As a part of the agreement with relatives, payments were occasionally made for lots in outside cemeteries. As a value of $35 was set on lots in Quabbin Park Cemetery, this was the limit set for such purchases. Under some circumstances, existing perpetual care funds were also increased in amounts to $100. This price was set for perpetual care funds in Quabbin Park Cemetery.

The first removals made by the Commission occurred in 1928. These were made to cemeteries outside of the reservoir area. On May 31, 1939, 945 bodies had been removed to outside cemeteries, and 5,384 bodies had been removed to Quabbin Park Cemetery. Approximately 780 bodies are yet to be removed. It is estimated that by the end of the season there will be 300 bodies remaining.

Quabbin Park Cemetery

Quabbin Park Cemetery is located south of Quabbin Reservoir, and below its watershed, in the northerly part of the town of Ware. It is attractively situated on high, dry, slightly rolling ground, and is sufficiently removed from the main road, Route 9, which passes its only entrance, to assure a quiet seclusion in keeping with its purpose.

The cemetery entrance, just west of the junction of the Ware-Belchertown highway and Quabbin Hill Road is marked by commemorating tablets. A winding drive passes a receiving vault which is unobtrusively cut into the adjoining hillside, and then continues across Blair Brook, a tributary of Beaver Brook, to a section which has been reserved for memorial purposes. At this point, also, the general development begins which provides for a total of 11,920 burials, with additional room for future development.

The layout provides for 1,490 eight-grave lots, which may be approached directly from the main drives totalling about 0.8 mile in length, or from paths with no crossing of adjoining lots. The drives are 20 ft. in width of gravel surfacing in the center of a 40-ft. location and the walks are 5 ft. wide. The lots are generally 16 ft. by 20 ft. A water supply system has been installed for the benefit of the cemetery. The system includes about 5,000 ft. of ¾-in. pipe and 16 self-closing faucets, having its source in a well located on a hillside about 2,000 ft. north of the main part of the cemetery and including a gravity pressure tank at the end of the system. The tank has a capacity of 275 gal. and is provided with cocks to allow testing of the water level and admission

of air, and the available capacity under the expected fluctuation of air pressure is about 75 gal. It has a controlled blow-off for drainage of the system during the winter months.

FIG. 14.—QUABBIN PARK CEMETERY.

All natural features have been preserved to the fullest extent. With the extensive planting which has already been accomplished, in collaboration with Arthur A. Shurcliff, Landscape Architect, this cemetery has become a source of pride to all who have been connected with its creation.

All public memorials formerly located in the abandoned towns have been reset as a group in the memorial section of the cemetery. They are effectively placed on either side of a grass panel having parallel walks leading to a utility building which is to be constructed. This building will provide facilities for public toilets and will be used also for storage of maintenance tools and materials. The memorials include: the Enfield Civil War Monument and Cannon; the Ballou Monument; and War Memorial and Cannon from Dana. War Service Honor Rolls from Prescott, Greenwich and Enfield will be preserved in the utility building.

The land required for this cemetery was taken by the Commission on June 5, 1931. A total of 82.22 acres was taken, of which only about 30 acres has been developed. On August 26, 1932, Quabbin

Park Cemetery lots became available to those persons who had an interest in the original Swift River Valley cemeteries, which on that day were closed to further interments. On May 31, 1939, 5,384 bodies, with the corresponding monuments and markers, had been brought to this cemetery, carefully reinterred and reset, with the lots brought to first-class condition. In addition to this, 4 bodies had been reinterred from outside cemeteries and 138 new interments had been made therein.

In accomplishing this work many problems had to be faced, most of them of a personal nature which required a high degree of tact and consideration. William W. Potter, one of the Commission's engineers, connected with this work since its inception, has ably carried on the many duties of contact with the interested persons and of supervision over all removals.

Early in the days of this water supply project, the Commission through newspaper and other publicity spread the warning that removals would be compulsory from cemeteries located in the Swift River towns of Belchertown, Dana, Enfield, Greenwich and Prescott. This resulted disastrously in one respect. Laborers of every type, craftsmen and professional men, through some uncontrolled grapevine system of false publicity learned that men were to be employed at unbelievably high wages under severe conditions of quarantine but otherwise under exceptionally fine living conditions, to excavate old graves, remove and reinter bodies, and then, perhaps, to receive a life pension. The field office at Enfield, then under the direction of Division Engineer N. LeRoy Hammond, was besieged with applications for employment. This rumor persisted for over 10 years. In one instance 2 men walked several hundred miles to make application.

In the desired respect, this publicity has worked well, although it has not been possible to reach representatives of all old burial lots. Where all attempts have failed, removals have been carefully made and records have been maintained so that future inquiries regarding burials may be as fully satisfied as though the old cemeteries still existed. Practically all inquiries were directed to the Enfield office and for the purpose of giving these prompt attention, a plan and a detailed census of each cemetery was made available at a very early date. Old cemetery plans or records were practically non-existent. Monuments and markers had become the record. From these, all possible data were copied, and the information thus obtained became invaluable for the purpose of interview and report. Many town records, including cemetery

records, have been lost because of fire, and it is conceivable that in some cases the only records of any nature were stored in the memories of a changing procession of cemetery officials and undertakers. One of the few existing records preserved at the Administration Building in Belchertown is a pine board upon which is burned a map of Woodlawn Cemetery, Enfield.

Until the completion and opening of Quabbin Park Cemetery in August, 1932, many removals were made to cemeteries in nearby localities, but beyond the limits of the reservoir drainage area. In every case the Commission received from the representative a release covering all rights in the original cemetery lot, signed by the nearest of kin or the person otherwise having the right to dispose of the bodies and burial place. Upon receipt of an inquiry regarding body removal, all facts as to burial place, inscriptions on monuments, number and size of monuments, and marker, were collected; an agreement with the representatives regarding the new lot either in an outside cemetery or in Quabbin Park Cemetery was reached, and disposition of perpetual care funds, if any, was arranged.

A report giving all these facts and giving the Division Engineer's recommendation as to removal, contribution toward purchase price of a new lot or toward perpetual care fund requirements if required, and a concise genealogical history, was prepared and forwarded to the Chief Engineer. This report was carefully compared with information on file at the headquarters office and was then condensed and a communication presented to the Commission by the Chief Engineer. Upon approval, releases were secured by the field office and then the recommended work was permitted to proceed. In the case of removals to Quabbin Park Cemetery, when the signed release was obtained, a cemetery deed, prepared by the field office, was executed by the Commission and held until a copy of "plan and interment record, Form 118", was received. This form contained a plan of the new lot with grave and marker locations, a record of grave locations in both old and new cemeteries and record of perpetual care fund, if any.

When delivery of the deed by the field office to the representative was made, a receipt was obtained and forwarded directly to the Secretary of the Commission. This marked the closing detail in every case, but many intervening details were maintained. One important one was the maintenance of Quabbin Park Cemetery Record Book, bound in hard covers and containing mounted white prints 19 by 27½ in., show-

ing first a lot index plan, scale 1 in. = 100 ft.; second, a plan showing location of driveways with all center line layout data, of the same scale, and third, 10 sheets showing lot details on scale of 1 in. = 20 ft. One set was kept at the headquarters office, one at Enfield, and one was recorded in the Registry of Deeds, Hampshire County, on July 1, 1932. The two books maintained by the engineering department were kept constantly up-to-date by entering the name of representative and release number.

The Secretary has been the custodian of the official releases and deeds. These are identified by a release number and the three papers necessary in each transaction are kept together and filed in numerical order in heavy covers. Records of removals to Quabbin Park Cemetery are marked with a series of numbers having the prefix "Q", signifying Quabbin. Removals, to outside cemeteries have an independent numerical system without prefix. As soon as a number has been assigned, its use becomes customary in the identification of correspondence and records. Unrepresented lots which contained burials were treated as distinct transactions and were identified with the prefix "U", signifying "Unrepresented". The numbers were included in the "Q" series, the purpose being to change the "U" to "Q" in case a representative appeared to assume responsibility.

For the government of Quabbin Park Cemetery a set of rules and regulations was adopted on June 28, 1932. A copy of these is contained in the Appendix.

A card system used for all removals was devised and has been maintained in duplicate by the field and headquarters offices. An orange card was used for information relating to the lot representative and lot details, and a white card was prepared giving all information relating to the deceased person. It is the present intention to compare these two sets which have been kept up independently before the completion of the work and to bring them to complete agreement.

Much of the routine office work of the field office was delayed each year until cold weather prevented removal work. Close checking by the headquarters office promptly found differences or omissions, and these were remedied at once. Nearly from the start all work connected with removals at the headquarters office followed a standard method, the only portion of the work requiring resourcefulness being the adaptation of genealogical facts for the purposes of the Chief Engineer's recommendation.

Provisions for the transfer of perpetual care of lots in the old cemeteries to lots in Quabbin Park Cemetery were included in Section 5 of Chapter 321, Acts of 1927. No actual transfers were made, however, until January, 1939, after specific legislation in House No. 961, Acts of the Commonwealth. The original funds amounting to $18,305.17 held by original cemetery authorities are at present accounted for in the following manner:

Transferred to Outside Cemeteries	$ 3,400.00
Transferred to Quabbin Park Cemetery in care of Treasurer of the Commonwealth. Held by M.D.W.S. Comm. for future transfer	$14,905.17
Total	$18,305.17

The original act authorizing the creation of Quabbin Park Cemetery was amended by House No. 961, January, 1939, placing the care and control of this cemetery under the Metropolitan District Water Supply Commission and at its expiration, in the control of the Metropolitan District Commission. Thus is assured a first-class cemetery under continued supervision.

Quabbin Park Cemetery has cost to date $102,956.33. This cost is broadly distributed as follows:

CEMETERY COSTS

Purchases and Settlements	$ 8,850.00
Construction	50,406.16
Water Supply System	1,251.97
Maintenance	18,675.32
Miscellaneous Expense	24,936.23
	$104,119.68
Revenues	1,163.35
Total Cost	$102,956.33

A total of 5,384 bodies has been removed from the older Swift River Valley cemeteries and reinterred in Quabbin Park Cemetery. Adding to this, 4 reinterments from outside cemeteries and 138 original interments makes a total of 5,526 completed burials. The labor and

incidental expense incurred for this work amounted to $68,570.13, a unit cost of $12.41 per body. A total of 945 bodies has been removed to cemeteries other than Quabbin Park Cemetery at a total cost of $29,444.65. The unit cost per body for removals of this type has reached $31.16. Based on the assumption that the total cost of Quabbin Park Cemetery will reach $105,000 and on an estimate of 6,166 bodies to be reinterred therein, at the unit cost of $12.41, the estimated total cost of the cemetery and interments will be $115,920, or about $18.80 per body.

Historical Notes

The early history of the Quabbin Reservoir region is very vague. It is known that it soon became a popular hunting ground and that the destructive policy of encircling game by a ring of fire, was practiced. The burnt-over lands, however, became covered with a species of wild grass and became useful as summer pasturage for cattle and horses from the settlements along the Connecticut River.

The region comprising the former towns of Enfield and Greenwich was formerly known as Quabbin, so named in honor of the chief of a tribe whose headquarters lay near the junction of the Middle and East branches of the Swift River. The translation of the name "Quabbin" is "Many Waters." By officially naming the new basin Quabbin Reservoir, the Commission in charge of the work has given this former chief a lasting memorial. The origin of the name "Quabbin" for this region is discussed by Mr. Kennison in his paper "Boston Metropolitan Water Supply Extension."

Belchertown, the former town of Enfield, and other nearby towns were included in territory claimed by the State of Connecticut, and all rights therein were sold in six equal divisions to seven Bostonians, in the year 1727. One of these was Jonathan Belcher who was later, from 1730 to 1741, Governor of the Province of Massachusetts Bay. These towns were a part of the region known as the Equivalent Lands, and the subject of an agreement between Connecticut and the Province of Massachusetts Bay, by which Massachusetts maintained jurisdiction over the towns of Woodstock, Somers, Enfield and Suffield in Connecticut. These Connecticut towns have, since 1740, been incorporated with that state. Attempts to settle "Cold Spring," now Belchertown, resulted in the arrival of several families during July, 1731. In 1737, a petition to the General Court stated that "they had twenty

families, and more expected soon." This small band of settlers was then planning to settle a minister and build a meeting house.

Descendants of the soldiers who had destroyed the Narragansett Fort on December 19, 1675, during King Philip's War were granted seven townships of land by the General Court on June 30, 1732. One of these townships, called Narragansett Township No. 4, was first laid out in New Hampshire, but as it proved unsatisfactory, better land was demanded. Quabbin was the tract of land chosen and is described as "bounded north by Salem Town, easterly by Lambstown (now Hardwick), southerly by the Equivalent Land, and westerly by Wm. Reed's land." The General Court made this exchange on January 14, 1736.

The earliest incorporation of a town in this territory is that of Hardwick in 1739, followed by Pelham in 1743, New Salem in 1753, and Greenwich and Petersham in 1754. Belchertown, Shutesbury and Ware were incorporated in 1761. Dana, Enfield and Prescott followed in the years 1801, 1816, and 1822.

The communities in the Swift River area grew rapidly until about 1850 when their collective maximum growth was reached. From this time on a rapid reduction in population took place. The four towns, now extinct, Prescott, Enfield, Dana and Greenwich, had in 1850 a population density of 46.6 per sq. mile. In 1925, just preceding the formation of the Metropolitan District Water Supply Commission, it had become 28.0 per sq. mile. In 1925, the Swift River watershed had a population of 21 per sq. mile. This had, because of activities of the Commission, fallen to 7.8 in 1937. A study of these population losses indicate a very regular rate. The responsible factor appears to have been the general migration to the newer agricultural regions of the Middle and Far West and to the prosperous industrial centers of New England and New York.

As in other New England communities, many ventures originated, flourished and failed along the banks of its streams. Among the manufactured products of the Swift River Valley towns were, woolen cloth, cotton cloth, palm leaf hats, boots and shoots, one-horse wagons and scythes. The Ware River towns manufactured most of these products and in addition, satinet, carriages, copper pumps and powder. Farming was until the last the chief occupation, with lumbering an important runner-up. Fish breeding, turkey raising and the collection of ferns were among the recent income-producting sources.

The most startling historical event coupled with this territory is Shays' Rebellion, which, planned in Conkey's Tavern in Pelham, organized and led by Captain Daniel Shays, was finally quelled by General Benjamin Lincoln on February 4, 1787. The Daniel Shays' Highway which parallels the westerly shore of Quabbin Reservoir has been named after this product of the uncertain period just following the American Revolution. Captain Shays represented the cause of many of his fellow veterans of that struggle, who had been promised much and received nothing. His unsuccessful attempt to right a wrong was continued by his fellow citizens in an orderly manner, and results were secured within the year. Daniel Shays has been vindicated in full. He eventually received a pardon and, during his last years, the Federal Government allowed him a pension for his valuable services as an officer during five years of the Revolution.

Many persons of distinction have called this region "home." The scope of this narrative does not permit a review of their histories. However, before closing, it seems not inappropriate to refer to a lady of prominence from this region, Dr. Mary B. Walker. She served as a surgeon during the Civil War, with honor to herself and her community, and because of the inconvenience of feminine dress, was granted the right by Congress to wear pants. Maybe she was symbolic of that vast majority of women that have always "Worn the pants." She, at any rate, set a style which appears to be very popular at all our vacation resorts. Aside from that, she placed herself among the pioneers who eventually gained political recognition of women.

The final days of Dana, Enfield, Greenwich and Prescott were marked by strange activities. The sale of buildings and their demolition soon reached the point where their absence was noticeable to even the casual visitor. The passing of the Athol Branch of the Boston and Albany Railroad was marked ceremoniously on June 1, 1935, by the last train which had as passengers many "old timers" from the valley. The removal of the railroad fixtures which soon followed, the advent and departure of the clearing crews, usually referred to as the "woodpeckers", the completion of Quabbin Dike and the slow but sure rise of Winsor Dam, clearly marked the new destiny of the Swift River Valley. Roads which for a century and more had been freely used by the public were closed, some by permanent barriers and some by guarded gates. Passes permitting entrance were issued upon application, and many persons availed themselves of the opportunity to see the valley for the last time.

The impression of desolation was general. Surprises, such as finding tar sidewalks in "the middle of nowhere", or of suddenly meeting a pair of does who looked upon you as objects of curiosity, were common. Perhaps an occasional glance at the little streams which were eventually to swell and raise the waters to that well-defined timber line, caused a mental picture to form of the completed reservoir, and perhaps a resolve was made to revisit the locality when the filling was accomplished.

Old familiar landmarks were missed and many persons who had intimately known the valley felt bewildered at times. The Commission maintained an alert patrol, and constant supervision was kept over the visitors for their protection. Upon departure, passes were relinquished and the visitor went gaily on his way along highways marked by route signs and cluttered with the advantages of civilization.

On April 8, 1938, Enfield held its final town meeting. The warrant contained 6 articles, one of which appropriated $1,800 for a memorial to be erected in Quabbin Park Cemetery to commemorate the bravery of the World War veterans of the town. The Worcester Daily *Telegram* of April 9, 1938, contained this sidelight "the town once ranked second to Brookline in the state in wealth per capita." The Quabbin Club, an active woman's organization in Enfield, held its final meeting on April 12, 1938. The club had lived for 40 years and one of its charter members, Mrs. Annie Williams Howe, was present at its closing session. On April 21, 1938, the town of Greenwich at its last town meeting also voted to erect a monument, appropriating $2,000 for the purpose. The *Boston Herald* of April 22, 1938, stated that 21 voters attended the meeting, and that typical of New England small town meetings, a number of children were present, the youngest being 14 months of age.

"Enfield dances into History. . . ." A function sponsored by the Enfield Fireman's Association, in a black-draped town hall brought more than 3,000 persons to Enfield on April 27, 1938. Many former residents were present and many stayed through until the midnight moment when the town passed out of existence. The occasion became a reunion for the residents of the Swift River Valley, entire families from the adjacent towns visiting with friends they had not seen for many years.

A striking illustration of this country as the land of opportunity is demonstrated by Cyprian Uracius, a Russian by birth, American

by adoption, the holder of 12 town offices of Greenwich. Mr. Uracius is acknowledged to have been the only "foreigner" in the valley. He certainly cannot longer be classed as such. The locality to which he has moved should quickly take advantage of the political experience which is his.

A branch telephone exchange of the New England Telephone and Telegraph Company at Enfield, in charge of Mr. and Mrs. Edwin Howe, closed on July 14, 1939. This service had been in operation continuously for 42 years. A private telephone concern known as the Highland Telephone Company, serving the most northerly towns in the valley, had gone out of existence on July 6, 1932. The rights in this company were acquired by the Commission from Catherine M. Connor and Mary F. Vaughan, both of these ladies having performed the duties of operators, managers and trouble crew.

As the population lessened, the U. S. Government finally closed all of the post offices in the reservoir area. There were 9 of these offices within the area affected by the reservoir when the Commission started its activity, located as follows: Cooleyville, Dana, Enfield, Greenwich, Greenwich Village, Millington, North Dana, North Prescott, Smiths. The most active of these and the last to be abolished were Millington, closed June 15; North Dana, closed July 15; Dana, closed July 30; Greenwich, closed Auust 30, 1938; and Enfield, closed January 14, 1939. The Dana post office ended its service on July 30, 1938. Important among its last day duties was the sending out of "last day covers" to philatelists from all parts of the country. This accounted for a record batch of 1632 letters sent out on that day. The other post offices on their last days collaborated with the philatelists in a similar manner.

The schools and churches in the valley ended their functions quietly. On June 22, 1938, the Enfield Grammar School held its final graduation, and 4 days later the Enfield Congregational Church held its final service, and on July 31 the Dana Congregational Church closed its doors.

In September, 1938, the Swift and Ware River valleys experienced, in common with a large adjoining area, a rainfall of unusual intensity. From the 12th, through the 21st, the total rainfall reported at Enfield was 14.29 inches and at Hubbardston, 17.69 inches. The resulting flood on the Ware River watershed broke all remembered

records. Its peak, reached at 11.15 A. M., September 21, was at the rate of about 9,040 m.g.d., or 145 c.f.s. per sq. mile of watershed.

The Swift River flood did not equal that of 1936 as the flow down the East Branch of the Swift River was deflected and retarded by the East Branch Baffle. The flood damage was comparatively slight in these watersheds, but nature struck again in the form of a hurricane which reached New England on September 21, 1938, causing immeasurable loss.

In the Swift and Ware River watersheds great damage was incurred in woodland areas particularly to stands of pine. It is estimated that in the vicinity of Quabbin Reservoir about 20,000,000 ft. of merchantable pine timber was blown down. In the Ware River watershed above Coldbrook the estimated quantity was about 3,000,000 ft. Salvage operations in coöperation with the Federal Government were instituted, and much timber was removed from these areas, lessening fire hazards and also increasing the revenue of the Commission to some extent.

The Commission's forces promptly cleared obstructions from roads and made necessary repairs to assure safety to those still resident in the Quabbin Reservoir area. Similar work was done in the Ware River watershed, and every possible assistance was given to other agencies at work during this emergency.

A permanent reminder of many who have lived here is contained in Quabbin Park Cemetery. To this beautiful, modern cemetery have been removed all civic memorials and most of the remains and monuments formerly located in the cemeteries scattered throughout the Quabbin Reservoir region. As a part of their duties, the Commission has assisted in the observation of recent Memorial Days by providing flowers and flags for the decoration of 211 soldiers' graves, veterans of all the wars in which this nation has participated. From present indications this practice will long be continued, for, while scattered in many communities, many former veterans representing this region will make an annual pilgrimage to this last resting place of their comrades.

Appendix

The following forms and records are believed to be of interest.

Form No.	*Size*	*Description*
Real Estate Forms		
28	Paper 8½"x14"	Property Blank

129	Paper 8½"x22" Folded—1st page	Appraisers Property Report
	2nd page	Descriptive Matter
	3rd page	Map—Site of Quabbin Reservoir
		Assessment Record & Appraisal
—	Paper 8½"x13"	Option
Cemetery Forms		
82	Card 4"x6"	Cemetery Record—Burials
83	Card 4"x6" Orange	Cemetery Record—Lot Ownership
116	Paper 8½"x14"	Cemetery Deed
117	Paper 8½"x14"	Release
118	Paper 8½"x14"	Plan of Burial Lot in Quabbin Park Cemetery and Record of Interments
Order 5748	Paper 5¾"x9"	Rules and Regulations
Miscellaneous		
Taking Document—Introductory Page		
Closing Page		Real Estate Requirements—Areas

PROPERTY BLANK

(Form No. 28)

To the Metropolitan District Water Supply Commission:—

The undersigned is the owner of the real estate on.....Street in the town of.....Distant.....miles from .....Nearest Village, Post Office or Railroad Station, consisting of.....acres of land and the following buildings thereon: .....room house, about.....years old. (Street number.....)

(Describe any other buildings)

Of said land.....acres is tillable;.....acres woodland.
Estimated value of wood and timber, $.....
I acquired title to said property, from.....
by deed dated.....recorded with.....
Deeds, book.....page..... The price paid by me was $.....
There is a first mortgage on the property, held by.....
upon which there is a balance due of $.....
(Give full particulars as to any other mortgages)
The property was assessed in

193 .	193 .	193 .
land $.....	land $.....	land $.....
buildings $.....	buildings $.....	buildings $.....
total $.....	total $.....	total $.....

There has been expended for improvements during the last five years the following amounts: (State nature of improvements)

The property is occupied by.....
There is a lease for.....years, expiring on the.....day of....., ...
The rent received is $.....per year.

I am willing to sell the above property to the Commonwealth for $.....
I desire to continue to occupy the premises until.....
Other information:

Date.....

.....
Signature of Owner

Address.....

METROPOLITAN DISTRICT WATER SUPPLY COMMISSION

Appraiser's Property Report

(Form No. 129)

Property of .....on..... Street, Road
Town of....., Distant.....miles from
.....Nearest Village, Post Office or Railroad
Station. Mark location of property on map on reverse side of this page.
Address of Owner.....
Use of property (residence, farm, woodland, etc.).....
Does owner occupy premises?.....
Area of land:.....acres tillage;.....pasture;.....woodland;.....total
Description of buildings (Age, condition, and improvements)
Water rights:
Mortgages:
First Mortgage: Mortgagee.....Amount.....Bal. due.....
Other Mortgages: Mortgagee.....Amount.....Bal. due.....
Names of tenants:
Rents now and formerly paid by tenants:
Has tenant a written lease, if so, date of same.....
Date of expiration of lease.....
Property was acquired from.....Date.....
Amount paid.....Date of Deed.....
Deed Recorded County.....Book.....Page.....
Improvements made during last five years:

Property assessed, 193 ,	land	$.....
	buildings	$.....
	total	$.....
193 ,	land	$.....
	buildings	$.....
	total	$.....
193 ,	land	$.....
	buildings	$.....
	total	$.....

What does owner want for property?
Your estimate, value of land

tillage	$.....
pasture	$.....

woodland $.....
buildings $.....
Total property $.....

Is property salable other than for water works purposes?
Do you recommend purchase with or without timber and buildings?
How long does tenant desire to remain in possession?
Reasons for valuation and other information for Commission:

Signature.....
Appraiser.

Date.....

We,
I, ...of.....in the County of.....and Commonwealth of Massachusetts, in consideration of one dollar and other valuable consideration, in hand paid by the Commonwealth of Massachusetts, acting through its Metropolitan District Water Supply Commission, the receipt whereof is hereby acknowledged, do hereby, for ....sel...., and.....respective heirs and assigns, grant to said Commonwealth of Massachusetts, the option of buying through said Commission for the price hereinafter named, the land herein described and in case said option is accepted in writing by said Commission or its duly authorized agent within .....days hereof,....hereby agree for ....sel.... and.....heirs and assigns to convey the same to said Commonwealth, said land being described as follows:—

Conveyance is to be made by a warranty deed. Title to the land above described is to be given to the satisfaction of said Commission or its counsel together with a release of any and all claims, debts, demands, damages, actions and liabilities both at law and in equity, past, present or future, of every nature and description, which....., ...heirs, administrators, executors, or assigns now have, ever had or may have, for any reason whatsoever against said Commonwealth or Metropolitan District Water Supply Commission and especially in carrying out the provisions in Chapter 375 of the Acts of 1926 and Chapter 321 of the Acts of 1927, but excepting any claim for the value of any other real estate hereafter purchased or taken from.....by said Commonwealth, and not included in the above described premises.

Taxes and any other encumbrances upon said estate are to be paid off prior to or simultaneously with payment to me or us or may be paid off by said Commission out of any moneys so coming to me or us, and taxes assessed for the year.....are to be apportioned as of the date of deed. The price hereby agreed upon for said property in case said option is exercised is..... dollars, which sum, upon the delivery of said deed, shall be certified to the Comptroller of the Commonwealth for payment. Full possession to said property to be delivered on.....

IN WITNESS WHEREOF, ...hereto set.....hands and common seal this.....day of.....A.D. 19.....

Witness:

....
.....

COMMONWEALTH OF MASSACHUSETTS

.....ss. ....., 19.....

Then personally appeared the above named.....
and acknowledged the above instrument to be.....free act and deed.

Before me,

.....

Justice of the Peace

My Commission expires

.....

Form No. 82

CEMETERY RECORD—BURIALS

Name of Deceased.....

ORIGINAL INTERMENT		REINTERMENT	
.....	.....	.....	.....
Cemetery	Town	Cemetery	Town
Block No....Lot No....Grave No.....		Block No....Lot No....Grave No.....	
Born ..... Died ..... Age		Reinterred ..... Box Size	
Record Book No. ..... Page		Undertaker	
Lot Representative		Remarks	
Address		.....	

Other Bodies in Common Interest

Name	Block No.	Lot No.	Grave No.
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....

Form No. 83

CEMETERY RECORD—LOT OWNERSHIP

Owner or Representative.....Address.....

ORIGINAL CEMETERY		NEW CEMETERY	
.....	.....	.....	.....
Cemetery	Town	Cemetery	Town
Block No....Lot No....No. Burials...		Block No. .....Lot No.	
Grave Nos.		Grave Nos.	
Lot Dimens. ..... Perpetual Care....		Lot Dimens. .....Perpetual Care.....	
Mons. ...Hdstns. ...Markers.....		Photo No.	
Removal Date		Deed (No. ..... Date.....	
Plan Acc. .....Photo No.		Recorded (Book ..... Page.....	
Record Book No. .....Page.....		Remarks	
Release No. .....Date.....			

Vol. 194

Other Interested Parties

Name	Address
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

Form No. 116

Cemetery Deed No.

QUABBIN PARK CEMETERY, WARE, MASSACHUSETTS

(Established for the reinterment of bodies removed from reservoir areas taken for supplementary water supply)

DEED TO BURIAL LOT

The Commonwealth of Massachusetts acting by and through its Metropolitan District Water Supply Commission hereinafter called the Grantor, under authority of Chapter 375 of the Acts of Massachusetts, 1926, Chapter 321 of the Acts of 1927, and every other power and authority hereto enabling, for consideration paid conveys to

a parcel of land in Quabbin Park Cemetery in the Town of Ware, County of Hampshire, Commonwealth of Massachusetts, being Lot No. .

in said cemetery as shown on plan bearing the inscription "Commonwealth of Massachusetts, Metr. Distr. Water Supply Commission, Quabbin Park Cemetery, Lot Index Plan, June 1, 1932", numbered Accession 3618, and also shown in detail on 10 plans of the same date and similar inscription, numbered Accessions 3640 to 3649 inclusive, recorded in the Registry of Deeds of said Hampshire County, July 1, 1932.

Said parcel is not to be used for any purpose other than burial of the remains of the human dead. This conveyance is made expressly subject to rules and regulations established from time to time by the Grantor or its successor in control and to the provisions of the statutes of the Commonwealth of Massachusetts now or hereafter in force.

In witness whereof the said Commonwealth of Massachusetts has caused this instrument to be executed by its Metropolitan District Water Supply Commission this .....day of.....in the year 19 .

Metropolitan District Water Supply Commission,

.....
.....
.....
} Commissioners

Recorded with the Records of Deeds of Burial Lots in Quabbin Park Cemetery of the Metropolitan District Water Supply Commission

Date..... Attest.....
Book..... Secretary

Form No. 117
Release, No. Q-
(Accompanying Deed No. to Lot in Quabbin Park Cemetery)
KNOW ALL MEN BY THESE PRESENTS,

That , , owner of parcel of land in Cemetery in the town of , County of , Commonwealth of Massachusetts, identified as Lot No . , containing about square feet and shown on a plan of the Metropolitan District Water Supply Commission of said Commonwealth entitled "
", number Accession , being the next of kin and the person having the right to represent and dispose of the remains of

buried in said lot, in consideration of the removal of said remains

by the said Commission as provided in Chapter 321, Acts of 1927 of said Commonwealth, to a burial lot in Quabbin Park Cemetery in the town of Ware, County of Hampshire, said Commonwealth, designated as Lot No. .

do hereby for , heirs, executors, administrators and assigns, remise, release and forever quitclaim unto the said Commonwealth, or its successors in interest, any and all right, title and interest in and to said parcel of land in said Cemetery together with any and all actions, causes of action, debts, dues, claims and demands which at law or in equity against the said Commonwealth or said Commission ever had, now have or may have for or by reason of the carrying out of the provisions of said Chapter 321.

IN WITNESS WHEREOF have hereunto set hand and seal this day of in the year 19 .
WITNESS .....
....
.....
.....
.....

THE COMMONWEALTH OF MASSACHUSETTS

....., ss. 19
Then personally appeared the above-named.....
and acknowledged the foregoing instrument to be free act and deed, before me,
My commission expires..... .....
Notary Public

Form No. 118

Accompanying Cemetery Deed No.

QUABBIN PARK CEMETERY, WARE, MASSACHUSETTS

The Commonwealth of Massachusetts to

Burial lot consisting of Lot No. .

as shown on plan bearing the inscription "Commonwealth of Massachusetts, Metr. Distr. Water Supply Commission, Quabbin Park Cemetery, Lot Index Plan, June 1, 1932", numbered Accession 3618, and also shown on detail Sheet , of the same date and similar inscription, numbered Accession , recorded in the Registry of Deeds of Hampshire County, July 1, 1932.

PLAN OF BURIAL LOT

Scale 20 feet to an inch. (■■ indicates headstone or monument)

RECORD OF INTERMENTS

Grave No.	Name	Date of		Headstone or Markers	Moved from			
		Death	Interment Herein		Cemetery	Block	Lot	Grave

Remarks.....Perpetual care.....

QUABBIN PARK CEMETERY, WARE, MASSACHUSETTS

RULES AND REGULATIONS

Adopted June 28, 1932

Revised Oct. 19, 1939

1. The word "Commission", as used herein, or a pronoun in place of it, means the Metropolitan District Water Supply Commission of Massachusetts or any other

Board or Officer duly authorized to act for the Commonwealth or any authority public or private to which the custody and control of Quabbin Park Cemetery may be transferred. The words "directed", "required", "permitted", "ordered", "designated", "prescribed", or words of like import mean the direction, requirement, permission, order, designation, prescription, etc., of the Commission or of its authorized agents; and similarly the words "approved", "acceptable", "satisfactory", or words of like import mean approved by or acceptable or satisfactory to the Commission or to its authorized agents, unless otherwise expressly stated.

2. Burial lots in Quabbin Park Cemetery, Ware, Massachusetts, newly established by the Commission, will be assigned and conveyed by the Commission upon application and upon the execution of a satisfactory release of lots in existing cemeteries within the reservoir area in the Swift River Valley and of an agreement in an approved form, to persons having existing rights as next of kin to bodies buried in, or having rights of burial in, such cemeteries as may be required to be removed under the provisions of Chapter 321 of the Acts of Massachusetts, 1927, or of any amendments or additions thereto. Burial lots will be sold by the Commission to other persons desiring to inter under such terms as it may from time to time prescribe. No person shall have the right of assignment of an area in any particular section of the cemetery, and the Commission may for cause set apart certain areas and prescribe special rules and regulations therefor.

3. Conveyances of burial lots shall in each case be consummated either by the execution of such a satisfactory release and agreement in an approvd form or by payment therefor and by the execution and delivery of a deed.

4. The words "burial lot" as used herein mean the parcel of land conveyed as hereinbefore described consisting of one or more or any portion or portions of the areas designated as lots on the plans referred to in the deed of conveyance.

5. Each burial lot shall be held indivisable and upon the death of the grantee the devisee of said lot or the heir-at-law shall be entitled to all the privileges of the original grantee, and if there be more than one devisee or heir-at-law, they shall, within nine months of said death, designate in writing to the Commission which of the said devisees or heirs-at-law shall represent the burial lot, and on their failure so to designate, the Commission will enter of record which of the devisees or heirs-at-law shall represent the lot while such failure continues.

6. No transfer of any burial lot or portion thereof or of exclusive burial rights therein shall be valid unless and until approved by the Commission. No burial will be permitted in any lot except upon a signed order of the grantee or his legal representatives approved by the Commission.

7. The grades of all burial lots will be established and corner bounds set by the Commission.

8. No trees, shrubs or flowers shall be planted upon any burial lot and no trees or shrubs within a lot shall be cut down or destroyed without approval. If any trees or shrubs in any burial lot shall become in any way detrimental to adjacent lots, drives, or paths, the Commission may remove such trees and shrubs or parts thereof as are deemed by it to be detrimental, dangerous or inconvenient.

9. Curbing, projecting corner posts, foot stones, fences, hedges, walks, artificial steps and mounds about or on any burial lot are prohibited unless specifically approved.

10. No monument, effigy, cenotaph or other structure shall be placed upon a burial

lot without approval. If any monument or structure or any inscription be placed in or upon a burial lot which shall be determined by the Commission to be sacrilegious or in any respect offensive or improper, the Commission may remove such monument, structure or inscription.

11. The entire cemetery area shall be exclusively devoted to and used for burial purposes. All persons are forbidden to needlessly walk across burial lots, to pick wild or cultivated flowers, or to dispose of rubbish of any kind in any place in the cemetery unless in repositories which may be provided therefor. Automobiles and other vehicles shall be excluded from all areas except roadways, and admitted to these only at such times and upon such conditions as the Commission may from time to time prescribe.

12. All monuments, markers and other permanent structures shall be placed upon concrete or other suitable foundations to satisfactory depths.

13. All work of whatever nature including the opening of graves and placing of foundations shall be done only by or under the direction of the Commission.

14. Perpetual care funds based upon a minimum charge of $100.00 for burial lots having an area of about 320 square feet or less may be accepted by the Commission and the income from any such fund will be used by the Commission for the care of the burial lot to which the fund applies. Burial lots not provided with perpetual care funds will be cared for upon the payment of an annual sum to be fixed by the Commission dependent upon the size of the lot. Payment for such care shall be made on or before April 1st to be effective in any calendar year.

15. A rental charge of $5.00, subject to change without notice, will be made for casket lowering mechanism and artificial green coverings furnished to undertakers by the Commission. The following charges, subject to change without notice, will be made for work done by this Commission: Interment and service charge, opening and closing of graves; over four feet long, April 1 to November 30, $12.00, December 1 to March 31, $15.00; less than 4 feet long April 1 to November 30, $6.00, December 1 to March 31, $7.00; concrete foundations $0.50 per cubic foot, minimum charge $2.00 for each foundation. Foundations will be placed only when the ground is free from frost. The foregoing charges do not apply to work required by Massachusetts statutes to be done by the Commission in connection with the removal of bodies from existing cemeteries in the reservoir area and removal and resetting of gravestones, monuments and markers.

16. The Commission assumes no responsibility for the unlawful acts of any person.

17. The tomb is for use during the winter months, and bodies may be placed therein and removed therefrom as ordered or approved by the Commission.

18. These rules and regulations are subject to amendment by the Commission from time to time.

Metropolitan District Water Supply Commission,

EUGENE C. HULTMAN, *Chairman*
THOMAS D. LAVELLE, *Associate Commissioner*
EDWARD J. KELLEY, *Associate Commissioner*

PUBLICATION OF THIS DOCUMENT APPROVED BY THE COMMISSION ON ADMINISTRATION AND FINANCE

ORDER OF TAKING
COMMONWEALTH OF MASSACHUSETTS,
METROPOLITAN DISTRICT WATER SUPPLY COMMISSION

No. 29.

Quabbin Reservoir. Boston, March 24, 1938

ORDERED: That the Metropolitan District Water Supply Commission acting herein by virtue of the authority conferred upon it by Chapter 321 of the Acts of the year 1927 and acts in amendment thereof or in addition thereto and every other power and authority hereto enabling, hereby take in fee in the name and behalf of the Commonwealth of Massachusetts for the purposes of said Act the land hereinafter described situated in the towns of Prescott, Enfield, Greenwich, Pelham, Belchertown and Ware in the County of Hampshire, the towns of Hardwick, Dana and Petersham in the County of Worcester, and the towns of Shutesbury, Orange and New Salem in the County of Franklin and Commonwealth of Massachusetts, shown on the plans hereinafter mentioned, copies of which shall be recorded with a copy of this order in the Hampshire County Registry of Deeds, the Worcester District Registry of Deeds and the Franklin County Registry of Deeds and made a part of this order, namely:

FIRST:

The land situated in said town of Prescott being shown on a plan entitled "Commonwealth of Massachusetts, Metropolitan District Water Supply Commission, Quabbin Reservoir, Land in Town of Prescott, Plan No. S 56 of Land Takings Under Chapter 321, Acts of 1927, . . . March 24, 1938, Frank E. Winsor, Chief Engineer," bounded and described as follows:

Beginning at the intersection of the town and county lines between Prescott, Hampshire County, New Salem, Franklin County, and Dana, Worcester County, as shown on said plan;

Thence the line runs south 8° 55′ 51″ east by said town and county line between Prescott, Hampshire County, and Dana, Worcester County, nine thousand six hundred eighty-six (9,686) feet to a monument;

Thence south 80° 19′ 03″ west by the town line between Prescott and Greenwich twelve thousand eight hundred ninety-two (12,892) feet to a monument;

. . . . . .

Thence north 78° 39′ 42″ east seven hundred fifty-nine and 8/10 (759.8) feet to the bound first mentioned and point of beginning: the last ten (10) courses and distances being by said town and county line between Prescott, Hampshire County, and New Salem, Franklin County: being shown on the aforesaid plan and comprising land of the following owners:

Name	Block	Lot	Acres
Commonwealth of Massachusets, formerly Milo W. Abbott Heirs	447	16	30.9
Commonwealth of Massachusetts, formerly Milo W. Abbott Heirs	447	28	22.4
Commonwealth of Massachusetts, formerly Milo W. Abbott Heirs	447	29	20.4
Commonwealth of Massachusetts, formerly Milo W. Abbott Heirs	448	2	13.9
Commonwealth of Massachusetts, formerly Loren M. and Hattie T. Adams	389	1	95.7
Commonwealth of Massachusetts, formerly West C. Aldrich	428	8	2.0

. . . . . .

There is included in this taking the fee and soil of all roads and highways and of all the lands in and under the ponds, great ponds, brooks, streams and rivers located within the above described areas, provided, however, that the amount of water to be let down into the Swift River as provided in Section 1 of the said Chapter 321 of the Acts of 1927, shall not be diminished by this taking, and provided further that this taking shall not be construed as a taking of the waters of the Swift River.

There is excepted and reserved from this taking such transmission lines, rights and easements of the New England Power Company and the Central Massachusetts Electric Company as now lawfully exist in and through lands herein taken and located in the towns of Belchertown, Ware, Enfield, Pelham, Dana, Petersham and New Salem located as and where shown on said plans.

There is excepted and reserved from this taking such rights and easements of the Gardner Electric Company, American Telephone and Telegraph Company, New England Telephone and Telegraph Company and the Highland Telephone Company as now lawfully exist in and through lands herein taken.

There is excepted and reserved to J. T. Sunderland and others lawfully entitled thereto a right of way for all purposes for which ways are commonly used in the Town of New Salem as and where shown on Plan No. S74

There is excepted from this taking such rights to care and control of highways included within the areas herein described as have been previously transferred to the Department of Public Works, and such easements for highway purposes as have been previously granted to the Worcester County Commissioners by the Metropolitan District Water Supply Commission.

Trees and structures upon the above described land are included in the taking with the exception of the towers, poles, wires and appurtenances of the New England Power Company, Central Massachusetts Electric Company, American Telephone and Telegraph Company, New England Telephone and Telegraph Company, Gardner Electric Company and the Highland Telephone Company.

A true copy.

ATTEST: .....

Secretary, Metropolitan District
Water Supply Commission

PICTURES AND PUBLIC RELATIONS AT WESTFIELD, MASS.

BY HARRY H. ANGELL*

[*Read March 21, 1940.*]

The Water Department of the City of Westfield, Massachusetts has developed a series of motion pictures designed to show the residents of the city the present development of their water supply, town forest, and some of the operations involved therein.

I would like to dwell a few moments on the advisability of a department developing such a series of pictures for the principal purpose of enlightening the public in their city as to what a valuable asset and a vital necessity a good and abundant supply of water may be. I need not go into detail in regard to the lack of interest expressed by the general public in its water system. We all have had the same general experience. No interest is expressed except at times of shut downs for repairs or emergencies, and there is criticism of officials if a shortage develops due to drought or breakdown of equipment or any other unavoidable cause. We also receive severe criticism at times of our water rates and management—especially during election campaigns—and of quality of water at certain times of the year. There are other unfavorable opinions with which you are familiar. We, in Westfield, feel that to a small degree at least we have eased this problem by favorable publicity through the presentation of these pictures.

We have appeared before service organizations in Westfield, namely the Kiwanis Club, Rotary Club, the Business and Professional Women's Club, the Church Men's Clubs at home and in two neighboring towns, and at the Westfield High School. On one occasion we remained at the High School for the entire school day showing hourly to each science class the pictorial development of the water supply. We have spoken also before forestry organizations such as the Western Massachusetts Forest Wardens' Association. This organization, after seeing the pictures of the Westfield Town Forest and the various fire scenes, asked for and received a repeat showing at a later meeting in the town of Lee.

*Deputy Superintendent, Westfield Water Department, Westfield, Mass.

Sunday night meetings with the Young People's Societies at the different churches have been numerous.

Actual favorable results traced directly to the showing of the pictures before our town people have been noted. Several instances have occurred wherein a property owner who was always on the back water rent list stepped into the office, a day or two after seeing the pictures and hearing our story, to pay his back indebtedness. One of our main critics, the operator of an ice manufacturing plant, called me up after the Rotary Club showing recently, saying how much he enjoyed the pictures and that he was pleased to have a chance to see and understand the workings of the system. I feel that in this case the department has gained a valuable ally. We have also noted an increased tendency by the public to visit our water sheds and reservoirs and a much more active interest in our town forest work.

PROCEEDINGS

February Meeting

Hotel Statler, Boston, Mass.

Thursday, February 15, 1940

President Percy A. Shaw in the chair.

Charles W. Sherman, of Metcalf and Eddy, Boston, Mass., read a paper "The Useful Life of Iron and Steel Standpipes."

The blizzard of February 14 reduced attendance and activities at this meeting.

March Meeting

Hotel Statler, Boston, Mass.

Thursday, March 21, 1940

President Percy A. Shaw in the chair.

Secretary Gifford announced the election to membership of:

John M. Littlefield, Clerk of Water District, Auburn, Me.; Albert H. Pye, Water Commissioner, Onset, Mass.; John W. Draper, Water Commissioner, Onset, Mass.; Samuel E. Eldridge, Water Commissioner, Onset, Mass.

On motion of George A. Sampson, duly seconded, it was VOTED that the president be empowered to appoint a nominating committee.

A paper "Hydraulic Investigation of a Small Water Works System and the Effects of Main Cleaning" was read by Richard H. Ellis, Engineer, Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston. Warren J. Scott, George K. Saurwein, E. Sherman Chase, and Howard E. Bailey took part in the discussion.

A paper "Explosives—Their Types and Uses," was read by C. H. Blocher, Explosives Division, E. I. duPont de Nemours Co., Inc., Boston. President Shaw, Roger W. Esty, Allan M. Symonds, and others participated in the discussion.

Harry H. Angell, Deputy Superintendent of the Water Department, Westfield, Mass., showed several reels of moving pictures of the Westfield water works and discussed the matter of public relations.

April Meeting

Vocational School, New Bedford, Mass.

Thursday, April 25, 1940

President Percy A. Shaw in the chair.

The Association was welcomed to New Bedford by Stephen H. Taylor, Superintendent of Water Works, and William R. Mackintosh, Director of the Vocational School.

Secretary Gifford announced the election to membership of:

Thomas Hart, Chief Engineer, Water Department, Peabody, Mass.; Clifford I. Tripp, Superintendent, Water Department, Mattapoisett, Mass.; Otto Hagmann, Clerk, Water Commissioners, Lincoln, Mass.

A paper "Description of Plumbing Testing Laboratories at the New Bedford Vocational School," was read by E. J. Sullivan, Assistant Engineer, Massachusetts Department of Public Health.

A moving picture "Back-siphonage" was shown by the Massachusetts Department of Public Health.

A paper "The Results of Better Maintenance and Sizing of Water Meters," prepared by Harold W. Griswold, Deputy Chief Engineer, Water Bureau, Metropolitan District of Hartford, Connecticut, was read by Warren A. Gentner.

A Progress Report of the Committee on Water Quality Tolerances for Industrial Uses was presented by Edward W. Moore, Assistant Professor of Sanitary Chemistry, Harvard Graduate School of Engineering, Cambridge, Mass. Frank A. Barbour discussed the report.

May Meeting

The May Meeting of the Association was held at the Cascade Lodge, on Route 1, between Saco and Portland, Maine, on Thursday, May 23, 1940.

President Percy A. Shaw in the chair.

The Association was welcomed to Maine by Edward S. Boulox, Commissioner, Portland Water District, Portland, Maine.

Secretary Gifford announced the election by the Executive Committee of the following new members:

Lester B. Hull, Superintendent, Water Department, Gloucester, Mass.; and Charles R. Moore, Assistant Superintendent, Water Department, Portland, Me.

A paper "Experiences in Corrosion Control at Biddeford, Maine," was read by Edwin T. McDowell, Superintendent, Biddeford and Saco Water Co., Biddeford, Me.

A gavel made of oak raised on the Portland plantations was presented by Fred J. Reny, Treasurer and General Manager of the Portland Water District, on behalf of the Maine Utilities Association, to Percy A. Shaw as President of the New Hampshire Water Utilities Association.

A paper "The Story of PWA in Maine Water Works," was read by Fred J. Reny, Treasurer and Manager, Portland Water District. President Shaw discussed the paper.

A paper "Studies of Frost Penetration," was read by Harry U. Fuller, Chief Engineer, Portland Water District, Portland, Me. H. L. Clark, Frank J. Gifford, Roger W. Esty, and President Shaw took part in the discussion.

A paper "Modern Engineering Practice and 2-inch Cast Iron Pressure Pipe," was read by C. D. Cox of the McWane Cast Iron Pipe Company. The paper was discussed by Roger W. Esty.

PROGRESS REPORT OF THE COMMITTEE ON QUALITY TOLERANCES OF WATER FOR INDUSTRIAL USES*

To the President and Members of the
New England Water Works Association

GENTLEMEN:

At the meeting of the Association held on November 17, 1938, there was appointed a committee to investigate and report on the quality of process water required by industry, with special regard to the limits of tolerance of substances known to interfere with industrial processes. The undersigned committee herewith presents its report.

GENERAL CONSIDERATIONS

In all industries that utilize water as a processing agent, there are probably maximal values of impurities that cannot be exceeded in the process water without damage to the product. In many industries and for many substances commonly present in natural waters, these maximal values are so high that they are rarely exceeded. However, in some industries, tolerances for certain impurities are relatively low, and it is desirable to establish the values of these tolerances for the guidance of both industrial operators and public water supply authorities.

Bearing in mind that the allowable limits of impurities in process water are affected by variations in the process and in the quality of product desired, the Committee has endeavored to select values that correspond to normal practice. It is recognized that not a few industrial plants will be found in which water of higher content of impurities than that specified in this report is utilized successfully. In general, however, the limits of impurities specified are believed to be those beyond which special corrective treatment of the water begins to be profitable. Unless otherwise noted, all values quoted represent determinations in accordance with Standard Methods of Water Analysis.

*The Committee on Quality Tolerances of Water for Industrial Uses has requested publication of this progress report in order to provoke discussion and promote correspondence between members of the Association and the Chairman of the Committee. The tolerances stated in the progress report are tentative and the report, in its present form, has not been accepted by the Association.

Water Requirements of Specific Industries

Steam Generation. With the increases in pressures that have come with modern steam boiler design and installation, there have arisen perplexing problems concerning the control of foaming, priming, scale formation, and corrosion.

Powell (1) has estimated that of 130 boilers installed in central stations between January, 1936, and September, 1937, about 63% were designed for pressures of over 500 lb. per sq. in., and of 206 boilers installed during the same period in all industries about 23% were so designed, and only about 33% for pressures of less than 300 lb. per sq. in.

With low pressures, tolerances are relatively high, since internal water treatment by the introduction of various boiler compounds is practicable. These compounds, however, should not be used until conditions of supply, evaporation and pressure have been studied. Furthermore, application should be made only under competent chemical control. Even with low pressures, external treatment is desirable to relieve the boiler water of an excessive amount of settleable solids. As operating pressures increase above 150 lb. per sq. in., the use of boiler compounds becomes less desirable, and it becomes necessary to provide feed water of higher quality. Many public water supplies are unsuitable for use at these pressures without treatment of the water for boiler feed service.

Because investigation has shown that embrittlement in boilers may be inhibited by maintaining a specified ratio of sulphate to total alkalinity, expressed in terms of sodium sulphate and sodium carbonate, respectively, the American Society of Mechanical Engineers has suggested for boiler pressures up to 150 lb. per sq. in. a 1:1 ratio, for pressures of 150 to 250 lb. per sq. in. a 2:1 ratio, and for pressures above 250 lb. per sq. in. a 3:1 ratio. However, recent investigations have led the A.S.M.E. to reconsider these ratios, which are to be used only until such time as a definitive report is issued.

Priming and foaming are caused by the accumulation of high concentrations of dissolved and suspended solids in the boiler. The magnitudes involved depend to some extent on the character of the feed water, but more on the design of the boiler, the amount of blowdown, the percentage of condensate returned, and other factors. When only a small portion of the condensate is returned, as in industries where steam is used in process, it is especially desirable to secure

feed water that is low in dissolved and suspended solids, as the amount of blowdown necessary is thereby diminished.

As operating pressures increase above 400 lb. per sq. in., quality requirements of feed water become very exacting. The most desirable water is that which most closely approaches deaerated distilled water. The hardness constituents must be reduced nearly to zero. Any appreciable amount of silica must be removed, since it combines with other substances to yield a variety of scale-forming complexes. For example, analcite, a double silicate of sodium and aluminum, is readily deposited in high pressure boilers as a dense scale.

Dissolved oxygen must be absent in the feed water used for boilers operated above 250 lb. pressure, because of corrosion of the boiler. Bicarbonates will hydrolize to hydroxides, and carbon dioxide, the latter making the condensate corrosive. Correction of feed water with respect to these substances is frequently accomplished by deaerating heaters or other equipment; hence it is difficult to specify general limits applicable to public water supplies. This is especially true of dissolved oxygen, which is present in substantial amounts in almost all public supplies.

TABLE 1—SUGGESTED LIMITS OF TOLERANCE FOR BOILER FEED WATER
(Parts per million, except for dissolved oxygen and pH)

Pressure (lb. per sq. in.)	0-150	150-250	250-400	Over 400
Turbidity	20	10	5	1
Color	80	40	5	2
Oxygen Consumed	15	10	4	3
Dissolved Oxygen**	2.0†	0.2†	0.0†	0.0†
Hydrogen Sulphide (H_2S)*	5	3	0	0
Total Hardness ($CaCO_3$)	80	40	10	2
Sulphate-Carbonate Ratio (A.S.M.E.) (Na_2SO_4: Na_2CO_3)	1:1	2:1	3:1	3:1
Aluminum Oxide (Al_2O_3)	5	0.5	0.05	0.01
Silica (SiO_2)	40	20	5	1
Bicarbonate (HCO_3)**	50	30	5	0
Carbonate (CO_3)	200	100	40	20
Hydroxide (OH)	50	40	30	15
Total Solids††	3000-500	2500-500	1500-100	50
pH Value (minimum)	8.0	8.4	9.0	9.6

*Except when odor in live steam would be objectionable.

**Limits applicable only to feed water entering boiler, not to original water supply. See text.

†Given as ml. per liter. Multiply by 0.70 for p.pm.

††Depends on design of boiler.

In actual practice, the permissible limits of impurities in a given boiler feed water will depend to a large extent on such factors as temperature, rate of evaporation, percentage of make-up water, and mechanical design of the boiler and its auxiliary equipment. The figures given in Table 1 are suggested only as a general guide for water-supply authorities. Steam plants operating at pressures above 250 lb. per sq. in. may be expected to require feed water treatment of some sort, since almost no public water supplies are suitable for direct use in such plants and in most cases the expense of rendering the entire water supply of a community suitable for such use would be prohibitive.

Cooling. Water for coolers and condensers should deposit no sediment or scale, but turbidity and hardness need not be particularly low. Control of corrosiveness is necessary, as is also the control of organisms that tend to form slimes, such as the iron and sulphur bacteria.

Air Conditioning. Any water suitable for condensing or cooling, and with tendencies to form slimes or corrosive action towards metals controlled by treatment, is satisfactory from an engineering standpoint for air conditioning. Waters that are unsuitable for air conditioning are those which give off odors, such as the odors of algae and hydrogen sulphide.

For the sake of economy, especially in large installations, it is often necessary to re-use the water used for air conditioning. The tolerances in this regard are esthetic and their establishment lies within the field of the designer and operator of air conditioning installations rather than in that of the supplier of water.

Pulp and Paper. The principal qualities of water that determine its suitability for pulp- and paper-making purposes are color, suspended matter, iron, manganese, hardness, and bacteria. Water of uniform composition and temperature is also desirable.

Water having little or no color is essential for the manufacture of most papers, except certain grades in which color and appearance are not important. For high-grade papers, such as writing, book, and other white papers, the color should not exceed 5 p.p.m., and for some products should be nearly zero. Colored papers in which the shade is important should also have water of about this quality.

Suspended matter (turbidity) is troublesome because it becomes entangled with the fibers and causes spots and other imperfections.

It may also decrease the brightness or strength of the paper. Tolerances range from 5 p.p.m. of turbidity for fine papers to as high as 50 p.p.m. for groundwood pulp. Organic matter is also undesirable, and it has been suggested that the oxygen consumed value of the process water should not exceed 10 to 20 p.p.m., depending on the grade of paper to be manufactured.

Iron is objectionable in water for paper mills since cellulose has the property of adsorbing iron from dilute solutions. This adsorption of iron causes a yellowing of white papers and a dulling of all shades of colored papers, particularly of the more delicate tints. It is also very objectionable in photographic papers. The amount of iron permissible depends on the grade of paper manufactured. For high-grade papers where color is important the water should contain less than 0.1 p.p.m. as Fe, although some high-grade writing-paper mills are operating with water the iron content of which ranges from 0.1 to 0.2 p.p.m. If the water is treated by coagulation and filtration, it should be possible to reduce the iron content to 0.05 p.p.m.

Manganese in paper mill water is extremely troublesome. It behaves somewhat like iron and causes similar staining and discoloration. It is also troublesome because of its tendency to clog pipe lines with black oxide deposits. It is very objectionable in bleaching operations, as the chlorine bleach will oxidize the manganese to permanganates, which impart a reddish color to the fibers. Tolerances for manganese are lower than those for iron; high-grade products may require water containing less than 0.05 p.p.m. as Mn.

Hard water is objectionable in washing pulp, particularly sulphite pulp, since insoluble calcium and magnesium resinates are formed and deposit on the fiber, making subsequent bleaching difficult. In the soda process, calcium and magnesium salts may be precipitated on the fiber by the caustic soda, carrying along coloring matters that are difficult to bleach. In the coloring of paper, carbonates may cause precipitation of the salts used as mordants. Soft water is desirable in the sizing operation since the mineral salts react with the rosin size and form insoluble resinates, which have no sizing action. Hard waters are objectionable because of the tendency to cause scale on pipes and other surfaces. This scale breaks away and causes trouble. While soft waters are more desirable, they are not absolutely essential, and many mills operate with hard water. Others, despite the expense of softening the large volumes of water involved, have installed or are considering softening plants.

Difficulties with sheet formation on the paper machine have been experienced in using water containing 25 p.p.m. of carbon dioxide; the permissible limit is probably in the vicinity of 10 p.p.m. However, the pH of the water should not be much over 7.3. Large amounts of silica in the water may make the paper "tinny", but definite limits have not yet been established.

Water for pulp and paper mills should be as free from bacteria as possible because of the tendency of these organisms to form slimes, which are objectionable in many ways. It is common practice to treat the water used in pulp and paper mills with chlorine or chloramine, so that slime difficulties are overcome to a large extent. A residual of 0.3 p.p.m. of chlorine or 0.8 p.p.m. of chloramine (as Cl_2) is suggested.

Textiles. The impurities that may be objectionable in water used for the processing of textiles are calcium, magnesium, iron, manganese, suspended matter, and soluble organic matter. Other objectionable impurities may be present in water under special conditions.

Iron is undoubtedly the most objectionable of all common impurities. It may be present in mechanical suspension, in colloidal solution, or in true solution. If in mechanical suspension, it may be completely removed by filtration; if in colloidal solution, it may or may not be completely removed, although the chances are that it will be reduced decidedly by filtration. If in true solution, it is not removed by filtration and is likely to be extremely harmful, even in small quantities. It may be completely removed by chemical treatment and filtration.

Concentrations of iron less than 0.25 p.p.m. as Fe are not considered a serious disadvantage for most purposes. Concentrations of 0.25 to 0.75 p.p.m. cause trouble from time to time. At concentrations between 0.75 and 1.00 p.p.m., iron is highly objectionable, and above 1.00 p.p.m. it becomes a constant menace in the processing of woolen goods, in bleacheries, and in many dyeing operations, and it should be removed if satisfactory results are to be secured. The limits given in this report for the amount of iron and manganese in water for textile purposes are intended to cover cases in which processes are sensitive to the presence of these two metals. There are textile processes where the quantity of iron and manganese might be increased beyond these amounts without giving serious trouble, for example where extreme whiteness is not essential in bleaching, or where dark colors are being dyed.

In rayon manufacturing plants, particularly those using the viscose process, the presence of minute quantities of iron and manganese is objectionable, and it is desirable in such plants to use a water which is as nearly free from iron and manganese as possible (0.02 p.p.m. or less). The Tubize Chatillon Corporation, Rome, Ga., specifies the following limits for water used in rayon manufacture: turbidity less than 0.3 p.p.m.; hardness 25 to 55 p.p.m.; pH 7.8 to 8.3; and no iron or manganese.

Manganese has effects similar to those of iron, and approximately the same limits apply. Calcium and magnesium are most objectionable on account of the formation of insoluble soaps. The quantities of calcium and magnesium present may be far greater than those of iron before any serious trouble occurs. Ten parts per million of either calcium or magnesium, expressed as $CaCO_3$, would not be objectionable in most instances. Any calcium and magnesium present in excess of this is a measure of the excess soap that would be required in any scouring operation. A few dyestuffs tend to be precipitated by calcium and magnesium. In certain dyeing operations calcium and magnesium are objectionable, but there are a few instances where their presence is of some advantage. One dyeing and bleaching plant specifies hardness less than 1 grain per gallon (17.1 p.p.m.), and a pH of 7.2 to 7.3. Vat and naphthol dyes apparently require water of higher quality than do direct, developed, or sulphur dyes. The formation of lime soaps is objectionable not only on account of soap waste, but also because of the sticky nature of these soaps and the difficulty encountered in their removal.

The nature and quantity of suspended matter present is influenced by local soil conditions, the time of year, and also by discharge of wastes into the stream. If necessary, it may be removed by sedimentation or filtration, with or without chemical treatment.

Soluble organic impurities are at times extremely objectionable, particularly if they impart color to the water. These impurities are frequently the most difficult to remove and are most objectionable in bleacheries. They also interfere with the dyeing of delicate tints on textile material. Water for textile purposes should have as little color as possible. In the scouring of wool, however, colors as high as 70 p.p.m. may be tolerated.

In the dyeing of textiles, uniformity in the composition of the water used is of considerable importance in duplicating shades. In

treated waters the residual alumina (as Al_2O_3) should not exceed 0.5 p.p.m., since larger concentrations cause irregularity in dyeing.

In a particular plant devoted to the manufacture of bandages, the specifications adopted for water quality are: color less than 5 p.p.m.; calcium and magnesium less than 8 p.p.m.; iron less than 0.2 p.p.m.; and freedom from taste and odor.

Laundering. Laundries are somewhat similar to textile plants in their water requirements, but are less exacting as to minimum tolerances. The most objectionable constituents are hardness, iron and manganese, and, if excessive, color and turbidity.

Brewing and Distilling. For typical light American brews, the mashing water should be aproximately neutral in reaction and low in alkalinity. Alkaline mash water leaches unfavorable elements from the grain and produces a darker, heavier, beer, with stronger, bitterer flavor. Dark beers may require a moderate alkalinity and a higher salinity. Some calcium sulphate (100 to 200 p.p.m.) is desirable for the best yeast development and may be added to the mash water. Iron and manganese are undesirable, since they combine with hop tannins to create an off-color and turbidity. Chlorinous or other tastes and odors should be eliminated. Unstable organic matter, measured approximately by the sum of color and oxygen consumed, may create a haze or mustiness during storage; the quantity present should be low enough to ensure that no precipitate will form during storage.

All water used to clean bottles and equipment must be potable, soft, and substantially free from taste, odor, iron and manganese.

In the distilling industry, the requirements for water quality are similar to those for brewing. For gin and spirits, the quality of mashing water should correspond to that for light beer; for whiskey, to that for dark beer. Water used for blending is usually distilled but may be produced from the regular supply by special treatment.

Carbonated Beverages. Requirements for water quality in the manufacture of carbonated beverages are similar to those in the brewing industry. Brilliant clarity and freedom from organic matter which may precipitate on standing are quite essential. The water may be tested by storing a fresh sample in a sterile glass-stoppered bottle for two weeks; if haze or sediment appears, the water should be treated. Free chlorine or chlorine complexes may react with extracts to produce unpalatability, or to bleach colors. Tastes and odors must be eliminated. For beverages with standardized acid content, the alka-

linity should not exceed 100 p.p.m., or better, 50 p.p.m., to avoid appreciable neutralization of acid and consequent loss of flavor or keeping quality.

Food Industries. In general, the preparation of food products requires potable, soft water, free from taste and odor, and low in iron and manganese. An exception to this is water to be used for baking, in which some hardness is desirable. The canning of leguminous vegetables requires water of hardness less than 75 p.p.m., if toughening of the vegetable fibre is to be avoided. In the manufacture of some forms of confectionery, dissolved solids should preferably be less than 100 p.p.m. Hard candy requires water with a pH value of 7.0 or above; a low pH value favors inversion of the sucrose and renders the product sticky. In making fondant, inversion of sucrose is desired, and distilled water or water of low pH value is preferred.

Artificial Ice. Water for the manufacture of artificial ice must conform to drinking water standards, particularly as regards bacteria, taste and odor, turbidity, and color. Iron, manganese, and silica will precipitate in the cake and produce opacity and discoloration; the allowable limits are 0.2 p.p.m. Fe, 0.2 p.p.m. Mn, and 10 p.p.m. SiO_2, respectively. Calcium and magnesium bicarbonates form gritty core deposits of normal carbonates, which leave a slime after the ice is melted. They may be removed by lime softening, or by the use of the recently-developed hydrogen zeolites.

Dissolved solids of any sort increase the difficulty of producing a clear cake in direct proportion to the amount present. According to Ehrenfeld and Gibbs (12), dissolved solids may be expressed in terms of "equivalent sulphates" (Total sulphates+0.75×total chorides+1.25 ×sodium carbonate), which should preferably be less than 10 grains per gallon (170 p.p.m.). Production of first-quality ice becomes difficult at "equivalent sulphate" concentrations above 10 grains per gallon (170 p.p.m.) and is impossible above 40 grains per gallon (680 p.p.m.). However, Burks (13) has shown that by improving the design and operation of freezing tanks, good ice can be made from water containing as much as 1300 p.p.m. of dissolved salts, especially when these salts consist of sodium chloride and sulphate. The improvements advocated by Burks entail an increase of 8.2 per cent in plant cost, and of 6.8 per cent in operating cost.

Tanning. Iron, manganese, or excessive turbidity create spots and discoloration in the tanning of hides and leather goods. The

process water used in coloring and fat liquoring of vegetable tannages should be low in hardness, which may stiffen or toughen the leather, precipitate tannins, oils and soaps, and have an adverse effect on the texture, color, and finish of the product. However, for the greater part of the tanning process, hardness is of slight significance. Production of white or light-colored leathers requires water the color of which does not exceed 10 to 20 p.p.m. For darker leathers, color may be as high as 100 p.p.m. Excessive alkalinity, especially caustic alkalinity, may give rise to difficulties in some parts of the vegetable tanning process.

Miscellaneous. There are a number of industries for which only general comment may be made as to requirements for water quality. Iron, manganese, and turbidity are objectionable in water to be used for the manufacture of ceramics and porcelain, cosmetics and soaps, pharmaceuticals, and photographic films. In addition, the manufacture of soaps and cosmetics requires water free from odor, and the production of some pharmaceuticals demands water of low organic matter content. The manufacture of water-white synthetic plastics requires water of extremely low color, turbidity, iron and manganese content.

The tolerances included in the progress report are summarized in Table 2.

Acknowledgments. The committee is indebted to Messrs. Sheppard T. Powell and W. D. Collins, who reviewed the report and made many valuable suggestions, and to Mr. K. E. Bell for criticism of the section on tanning.

Respectfully submitted,

EDWARD W. MOORE, *Chairman*
ROBERT SPURR WESTON
HERVEY J. SKINNER
FRANKLIN J. LAMMERS
LEWIS OLNEY
STUART E. COBURN
MERRITT E. CUTTING

Industry or Use	Allowable Limits in p.p.m. Turbidity	Color	Hardness as $CaCO_3$	Iron as Fe	Manganese as Mn	Total Solids	Alkalinity as $CaCO_3$	Odor Taste	Hydrogen Sulphide	Other Requirements**
Air Conditioning	—	—	—	0.5*	0.5	—	—	Low	1	No corrosiveness, slime formation.
Baking	10	10	—	0.2*	0.2	—	—	Low	0.2	P.**
Boiler Feed	—	—	—	—	—	—	—	—	—	See Table 1.
Brewing, light beer	10	—	—	0.1*	0.1	500	75	Low	0.2	P. NaCl less than 275 p.p.m. (pH 6.5-7.0)
dark beer	10	—	—	0.1*	0.1	1000	150	Low	0.2	P. NaCl less than 275 p.p.m. (pH 7.0 or more)
Canning, legumes	10	—	25-75	0.2*	0.2	—	—	Low	1	P
general	10	—	—	0.2*	0.2	—	—	Low	1	P
Carbonated Beverages	2	10	250	0.2 (0.3*)	0.2	850	50-100	Low	0.2	P. Organic color plus oxygen consumed less than 10 p.p.m.
Confectionery	—	—	—	0.2*	0.2	100	—	Low	0.2	P. See text.
Cooling	50	—	50	0.5*	0.5	—	—	—	5	No corrosiveness, slime formation.
Distilling	—	—	—	—	—	—	—	—	—	See text.
Food, general	10	—	—	0.2*	0.2	—	—	Low	—	P.
Ice	5	5	—	0.2*	0.2	See text	—	Low	—	P. SiO_2 less than 10 p.p.m.
Laundering	—	—	50	0.2*	0.2	—	—	—	—	
Plastics, clear, uncolored	2	2	—	0.02*	0.02	200	—	—	—	
Paper and Plup, groundwood	50	20	180	1.0*	0.5	—	—	—	—	No grit, corrosiveness.
Kraft pulp	25	15	100	0.2*	0.1	300	—	—	—	
soda and sulphite	15	10	100	0.1*	0.05	200	—	—	—	
high-grade light papers	5	5	50	0.1*	0.05	200	—	—	—	No slime formation.
Rayon (Viscose), pulp production	5	5	8	0.05*	0.03	100	Total 50 Hydroxide 8	—	—	Al_2O_3 less than 8 p.p.m. SiO_2 less than 25 p.p.m. Cu less than 5 p.p.m.
manufacture	0.3	—	55	0.0	0.0	—	—	—	—	pH 7.8 to 8.3.
Tanning	20	10-100	50-135	0.2*	0.2	—	Total 135 Hydroxide 8	—	—	
Textiles, general	5	20	—	0.25	0.25	—	—	—	—	
dyeing	5	5-20	—	0.25*	0.25	200	—	—	—	Constant composition. Residual alumina less than 0.5 p.p.m.
Wool scouring	—	70	—	1.0*	1.0	—	—	—	—	
Cotton bandage	5	5	—	0.2*	0.2	—	—	Low	—	

*Limit given applies to both iron alone, and the sum of iron and manganese.
**P indicates that potable water, conforming to U.S.P.H.S. standards, is necessary.

References

1. Powell, S. T. Treatment of Water for Industrial and Boiler Feed Uses. This Journal **52**, 435 (1938).
2. Powell, S. T. Water As an Engineering and Industrial Material. Proc. Am. Soc. for Testing Materials **34**, 3 (1934).
3. Powell, S. T. Effect of Salinity on Value of Water for Industrial Purposes Jour. Am. Water Works Association **25**, 226 (1933).
4. Powell, S. T. Boiler Feedwater Treatment for High Pressure Boilers. Paper Trade Jour., Sept. 11, 1938.
5. Powell, S. T., Carpenter, L. V., and Coates, J. J. Complex Silicate Scales in High Pressure Boilers. Combustion **11**, 18 (1939).
6. Skinner, H. J. Water Quality Requirements for New England Industries. This Journal **52**, 403 (1938).
7. Collins, W. D. Industrial Uses of Water. This Journal **52**, 396 (1938).
8. Collins, W. D. Water for Industrial Purposes. Amer. City, July 1937, pp. 52-54, August 1937, pp. 55-58, Sept. 1937, pp. 75-76.
9. Lammers, F. J. Water Purificaton in the Modern Brewery and Distillery. Ind. Eng. Chem. **26**, 1133 (1934).
10. Lammers, F. J. Taste, Odor and Alkalinity Control in Modern Beverage Water Purification. National Bottlers' Gazette, November 1934.
11. Lammers, F. J. Carbonaceous Zeolites for Brewing Waters. Modern Brewer, July 1939.
12. Ehrenfeld and Gibbs. Water for Ice Making and Refrigeration. (Book) Nickerson and Collins, 1928.
13. Burks, D., Jr. Treatment of Water for Ice Manufacture. Illinois Engineering Experiment Station Bulletins 219 (1930), and 253 (1933).
14. Burks, D., Jr. Production of Ice at Low Brine Temperatures. Illinois Engineering Experiment Station Bulletin 254 (1933).
15. Hibbard, P. L. The Significance of Mineral Matter in Water. Jour. Am. Water Works Association **26**, 884 (1934).
16. Foulk, C. W. Industrial Water Supplies of Ohio. Geol. Survey of Ohio, 4th Series, Bulletin No. 29.

Discussion

Samuel M. Ellsworth.* The Committee on Quality Tolerances of Water for Industrial Uses has performed a distinct service to the water works profession and deserves the commendation of the Association for the contribution made to this broad and complex subject. It is recognized in the opening paragraphs of the Report that the limits of impurities in industrial water supplies are affected by variations in processes and by the desired quality of the manufactured product. This is most important, inasmuch as many well-known industries have been manufacturing marketable products with notable success despite the fact that impurities of process water have greatly exceeded the highest limits suggested by the Committee.

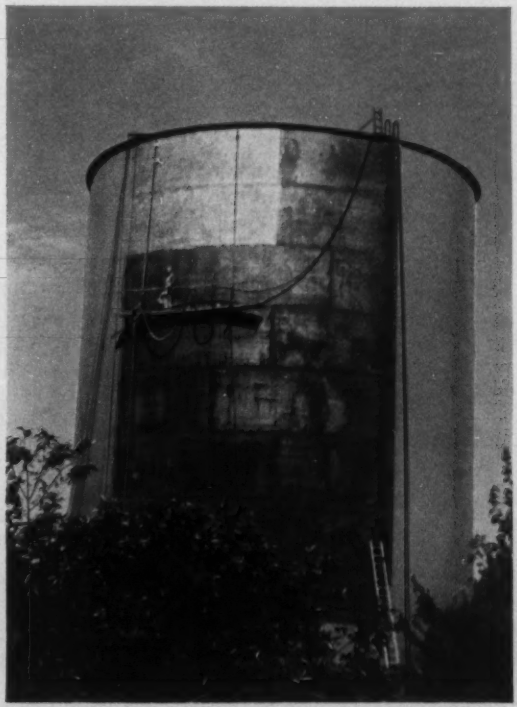
At the meeting of the Association in New Bedford in April, 1940, when the Committee's Report was presented, it was voted to have the Committee continue its studies. Since most of those attending the New Bedford meeting had had no opportunity to make a critical study of the Report, there was relatively little discussion. Frank A. Barbour commented briefly on the section of the Report dealing with "Textiles". He referred to the results of recent investigations relative to the effects of iron and manganese in water used in the processing of cotton duck and similar fabrics. These investigations had been undertaken in connection with litigation, wherein a textile mill in Central Massachusetts, having brought suit against the Commonwealth, claimed among other things that the increase in iron and manganese following the impounding of a surface water supply would require the construction of treatment works for the removal of these substances. While the claim was made by the mill that 1 p.p.m. of either iron or manganese, or a combination of the two, would make such treatment necessary, it was shown experimentally by the Commonwealth that several times this concentration would have no material effect on the processing of the goods. Evidence was also introduced showing that one of the outstanding cotton bleacheries in New England has for many years been using unfiltered surface water which frequently contains iron in amounts up to 1.5 to 2.0 p.p.m. and, in addition, undetermined amounts of manganese, all without any material effect on the quality of the finished product.

*Consulting Engineer, Boston, Mass.

Having been actively associated with this litigation and intimately acquainted with the evidence presented by some of the textile chemists, I am convinced that the conventional limits for iron and manganese in water used for textile processing can be quite misleading With the wide spread between the limits suggested by the Committee on Quality Tolerances and actual practice in an outstanding cotton bleachery, it is not unreasonable to assume that the limits suggested for other industrial processes may also be at variance with actual practice.

All of this suggests to me the need of gathering and presenting additional factual evidence. Too often the exact reasons for processing difficulties are obscure. The water chemist is not generally acquainted with industrial chemistry; nor are many industrial chemists intimately acquainted with water chemistry. Unless the two are engaged on the same problem, one supplementing the other in a study of causes and effects, the solution of processing difficulties may be left to hit or miss procedures, with the exact causes of the difficulties remaining obscure. Considering the water works field at large, the Committee would in my opinion greatly enhance the value of its recent Report by citing actual examples, not only of industries which have had unfortunate results from impurities in process water, but also those which have used successfully waters containing what might be considered excessive concentrations of so-called impurities.

Finally, may I be pardoned in presenting my conception of what the ultimate objectives of the Committee should be. In the last analysis I feel that they should center on the welfare of the manufacturer. The problem is essentially one of industrial economy, rather than an academic problem in water chemistry. If an unfiltered and untreated water can be used by an industry successfully without any deleterious effect upon the quality or marketability of the product, it would be poor business to provide treatment facilities simply because certain impurities were present in amounts far in excess of academic or conventional limits. On the other hand, if the cost of manufacture or the reputation of the product is seriously affected by the use of a low-grade process water, then treatment, or a new source of supply, may be justified. If the Committee is in agreement with this conception of its objectives, then it will search as diligently for examples of poor-quality waters being used successfully as for examples of the disastrous effects of small amounts of impurities on industrial processing.



Photograph by W. J. Lumbert

The first and largest all butt-welded
Standpipe in New England

SANDBLASTED AND PAINTED

by

J. H. TREDENNICK, INC.

10 HIGH STREET
BOSTON, MASS.
Telephones: Liberty 2480—Parkway 0285

STANDPIPE PAINTING

The problem of painting your standpipe, in all probability, does not involve the costly treatment pictured on the preceding page. This procedure is recommended only for new standpipes, standpipes previously painted over mill scale, and those not painted for so long that they are badly pitted.

The ordinary repaint job requires good paint, a thorough cleaning job, and experienced and trained artesans. The leading paint manufacturers have spent years in experimentation and millions of dollars in developing paints to meet your requirements. J. H. TREDENNICK, INC., has spent over thirty years in developing the most up-to-date cleaning methods and training men in the best painting technique. Our power wire brushing system is known throughout New England, and we suggest that you seek your paint supplier's opinion regarding the advisability, the economy, and even the necessity of our thorough cleaning methods.

We have successfully completed the painting of the following standpipes, during the past two seasons:

Westerly
East Providence
North Attleboro
Hanover
Scituate
Marshfield
Quincy
Marblehead
Brookfield
Winthrop
Reading

We number among our customers such consumers as:

American Oil Company
Gulf Oil Corporation
Atlantic Refining Company
New England Power Company
Stone & Webster, Incorporated
General Electric Company

Should you wish to discuss the maintenance of your standpipe, call or write

J. H. TREDENNICK, INC.

10 HIGH STREET

BOSTON, MASS.

Telephones: Liberty 2480 Parkway 0285

INDEX OF ADVERTISERS

	Page
Atlas Mineral Products Co.	xxix
Bailey, Howard E.	iii
Barbour, Frank A.	ii
Barrett Co., The	xxv
Barrows, H. K.	ii
Bingham & Taylor	iv
Builders Iron Foundry	xvii
Caldwell, George A., Co.	xxxvii
Cement Lined Pipe Co.	viii
Commodore, The	xxviii
Crosby, Irving B.	iii
Darling Valve & Mfg. Co.	ix
Donaldson Iron Co.	xxix
Dresser Mfg. Co.	Following front cover
Eddy Valve Co.	xv
Edson Corp., The	xxii
Ellsworth, Samuel M.	ii
Eureka Pipe Co., Inc.	iii
Fairbanks-Morse Co.	xxiv
Fay, Spofford & Thorndike	ii
Ford Meter Box Co.	xvi
Goodnough, X. Henry, Inc.	ii
Hays Mfg. Co.	xviii
Hersey Mfg. Co.	v
Hydraulic Development Corp.	x
Industrial Chemical Sales Division—West Virginia Pulp and Paper Co.	xix
Jackson, Henry D.	iii
Johns-Manville	xi
Keasbey & Mattison Co.	xxvii
Kennedy Valve Mfg. Co.	xiv
Knowles, Morris, Inc.	ii
Leadite Co.	Back cover
Lock Joint Pipe Co.	Facing front cover
Ludlow Valve Mfg. Co.	xvii
Metcalf & Eddy	ii
Morris Machine Works	xxvi
Mueller Co.	xxxv
National-Boston Lead Co.	xvi
National Gunite Contracting Co.	iii
National Meter Co.	xii
National Water Main Cleaning Co.	viii
Neptune Meter Co.	vi
New England Water Works Association	iii, xiii
Newsom, Reeves	ii
Pierce-Perry Co.	viii
Pirnie, Malcolm	ii
Pitometer Company	ii
Pittsburg Equitable Meter Co.	Following front cover
Potts, Clyde	iii
Red Hed Mfg. Co.	xxxvi
Rensselaer Valve Co.	xxiii
Reppucci, C. & Sons, Inc.	iii
Ross Valve Mfg. Co.	viii
Smith, The A. P., Mfg. Co.	xvi
Tredennick, J. H., Inc.	Preceding index of advertisers
Turbine Equipment Co.	xx
U. S. Pipe and Foundry Co.	Facing back cover
Wailes Dove-Hermiston Corp.	xxiii
Wallace & Tiernan	xxi
Warren Foundry and Pipe Corp.	xxii
Weston & Sampson	iii
Whitman & Howard	iii
Wood, R. D., Co.	xxx
Worthington Pump and Machinery Corp.	vii

(Classified index on page xxxi)

ENGINEERS

FRANK A. BARBOUR
Consulting Engineer

Water Supply, Water Purification, Sewer and Sewage Disposal, Valuations

Tremont Building, Boston, Mass.

H. K. BARROWS
M. Am. Soc. C. E.
Consulting Hydraulic Engineer

Water Power, Water Supply, Sewerage, Drainage, Investigations, Reports, Valuations, Designs, Supervision of Construction

BOSTON, MASS. 6 BEACON ST.

Samuel M. Ellsworth
M. Am. Soc. C. E.
Consulting Engineer
Water Supply and Sewerage
Investigations, Reports and Designs, Supervision of Construction and Operation
12 Pearl Street, Boston

FAY, SPOFFORD & THORNDIKE
ENGINEERS
Frederic H. Fay — Charles M. Spofford
John Ayer — Bion A. Bowman
Carroll A. Farwell — Ralph W. Horne
Water Supply—Sewerage—Drainage
Structural and Foundation Problems
Investigations Reports Designs Valuations Engineering Supervision
11 BEACON STREET BOSTON

THE PITOMETER COMPANY
ENGINEERS
Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings
50 Church Street New York City

REEVES NEWSOM
Engineer-Consultant
WATER WORKS—SEWERAGE
Construction and Operation
Investigation and Design
Valuation and Rates
500 Fifth Avenue New York — Telegraph Bldg. Harrisburg

X. HENRY GOODNOUGH, Inc.
Engineers
BAYARD F. SNOW
Water Supply, Drainage, Sewerage, Sewage Disposal, River Improvement, Disposal of Municipal and Industrial Wastes
14 BEACON ST. BOSTON, MASS.

METCALF & EDDY
ENGINEERS
Water, Sewage, Drainage, Garbage and Industrial Wastes Problems
Laboratories Valuations
BOSTON, MASS.
Statler Building

MALCOLM PIRNIE
ENGINEER
Water Supply, Treatment, Sewerage
Reports, Plans, Estimates,
Supervision and Operation,
Valuation and Rates.
25 West 43rd Street, New York, N. Y.

MORRIS KNOWLES, INC.
Engineers
Water Supply and Purification, Sewerage and Sewage Disposal, Industrial Wastes, Valuations, Laboratory, City Planning.
507 Westinghouse Bldg.
Pittsburgh, Pa.

ENGINEERS

WESTON & SAMPSON

Consulting Engineers

Robert Spurr Weston George A. Sampson

Water Supply and Sewerage
Chemical and Bacteriological Laboratory

14 BEACON ST. BOSTON, MASS.

WHITMAN & HOWARD

HARRY W. CLARK, Associate

Civil Engineers

(Est. 1869. Inc. 1924.)

Investigations, Designs, Estimates, Reports and Supervision, Valuations, etc., in all Water Works and Sewerage Problems

89 BROAD ST. BOSTON, MASS.

IRVING B. CROSBY

Consulting Engineering Geologist

Investigations of Dam and Reservoir Sites and Groundwater Supplies

6 BEACON ST. BOSTON, MASS.

HOWARD E. BAILEY

Consulting Sanitary Engineer

Water Works Water Purification
Sewerage Sewage Treatment
Industrial Wastes Disposal

177 State St., Boston, Mass.

RESERVOIRS and TANKS LINED and RESTORED
with
GUNITE
NATIONAL GUNITE CONTRACTING COMPANY
Engineers and Contractors
82 W. Dedham St. BOSTON

Potts, Clyde

M. Am. Soc. C. E.
Consulting Sanitary Engineer

Sewerage and Sewage Disposal, Water Works and Water Supply Reports. Plans and Estimates.

New York City, 30 Church St.

C. REPPUCCI & SONS, INC.

GENERAL CONTRACTORS

Ground Water Supply

Gravel Packed Wells Driven Wells
Water Works Reservoirs

Drainage and Sewerage Works

10 Garden Court Street (Tel. Lafayette 7330) Boston, Mass.

Specify

EUREKA CENTRIFUGAL CEMENT LINED PIPE

EUREKA PIPE CO., Inc.

591-593 Washington St., Lynn, Mass.
Tel. LYnn 3-9550

FRICTION

That is what makes valves work hard and ruins pump shafts and rods, ACE # 4 and # 90 eliminate friction, save wear, save valve stems. Ask for Bulletin # 110 and see why. Many industrial and light and power plants use it. They find it best by test. So will you. TRY IT.

H. D. JACKSON, Agent
29 Noyes St., Concord, N. H.

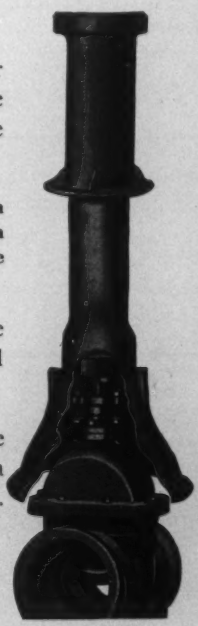
BINGHAM & TAYLOR'S Sliding Type Service and Valve Boxes are meeting with the approval of many New England Waterworks officials.

The cuts shown are our two and three piece sliding type adjustable valve boxes.

The flange on the bottom of the top section can be located any distance from the top.

We carry a complete stock on hand at all times.

Wire, phone or write us when you are in a hurry for a shipment.



ESTABLISHED 1849

B AND T

Bingham and Taylor Corporation

MANUFACTURERS

575-601 Howard Street - - Buffalo, N. Y.

orrents or Dribbles

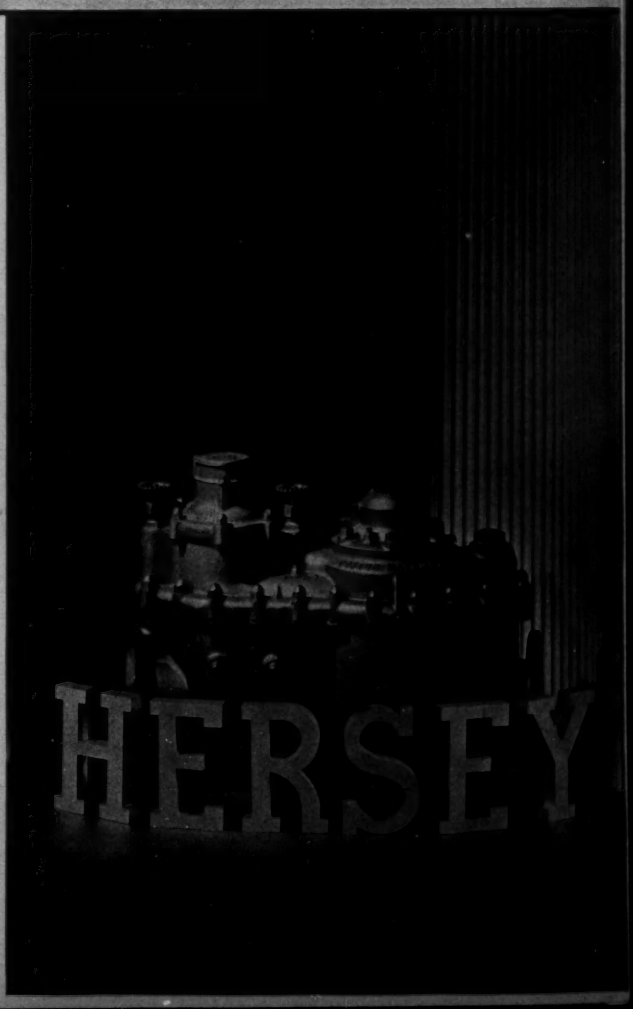
ne distinctive feature
of the
HERSEY
OMPOUND
METER

the linking together
a meter adapted to
asure large rates of
w with one adapted
measure small rates
flow, in an integral
vice and in a single
ing, by means of a
chanical compound
e Lever Valve, so
t they co-ordinate in
curately measuring a
ide range of flows.

bronze case to 6".

HERSEY
ANUFACTURING
COMPANY
OUTH BOSTON, MASS.

BRANCH OFFICES:
w York—Portland, Ore.
iladelphia — Atlanta
las — Chicago — San
ncisco — Los Angeles



TRIDENT Meters

WHEN YOU BOUGHT

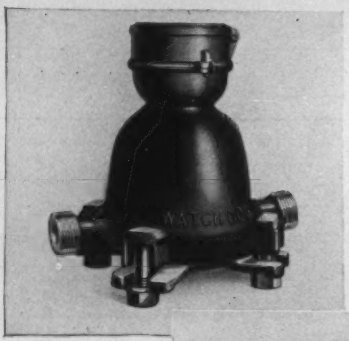
this meter in 1899, you never thought that you would be able to buy new parts for it in 1940, parts that would make it still more accurate; and that there would be few new meters which would surpass it.

When you buy Trident Meters today, Neptune's policy of Interchangeability assures you that you will be able to do this same thing 40 years from now.

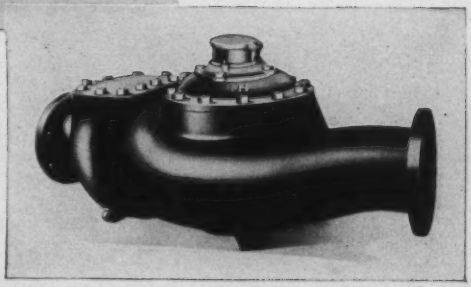
NEPTUNE METER CO.

NEPTUNE METER COMPANY - 50 West 50th Street, NEW YORK CITY
Branch Offices in Chicago, San Francisco, Portland, Ore., Denver, Dallas, Kansas City, Louisville, Atlanta, Boston.
Neptune Meters, Ltd., 345 Sorauren Avenue, Toronto, Canada

WATCH DOG METERS



Frost-proof meter



Turbine meter

Investigate these meters

WHEN looking over your requirements, remember that thousands of municipalities are getting satisfactory low-cost service from Worthington-Gamon Meters.

WORTHINGTON-GAMON METER COMPANY

General Offices: HARRISON, NEW JERSEY

Offices and Representatives in Principal Cities

WORTHINGTON-GAMON

WGS-4

THE STANDARD FOR OVER 50 YEARS

Automatic Pressure Control Valves
Water Works Specialties

Altitude — Pressure Reducing — Surge
Relief and Combination Valves
Portable Fire Hydrants
Hydraulic Booster Pumps

ROSS VALVE MFG. CO., Inc. Troy, N.Y.

Health and Protection First

Water delivered through dirty pipes
may be a MENACE.

Incrusted water pipes mean inefficiency
and loss of Fire Protection.

We Guarantee the Results of Our
Method of Cleaning.

WRITE US.

National Water Main Cleaning Co.
50 Church Street New York City

Cement Lined Service Pipe

Cement lined pipe has eliminated corrosion and metal contamination for 60 years

Write for Literature

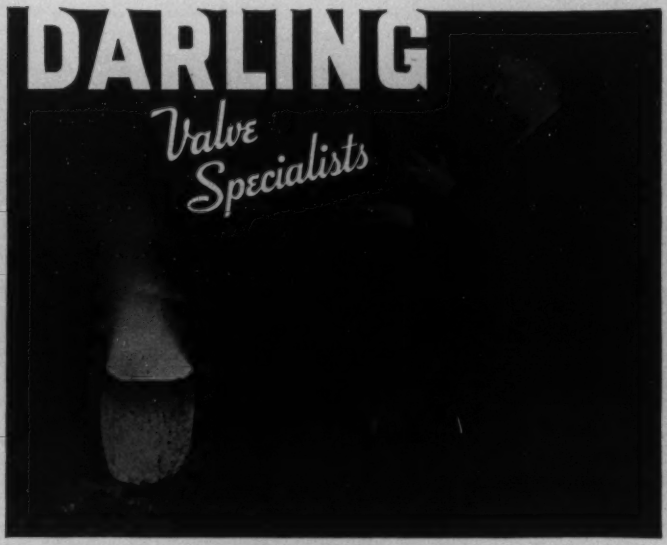
Cement Lined Pipe Co.
Lynn, Mass.

PIERCE - PERRY CO.

Wholesalers of

Water Works Brass Goods.
Byers Wrought Iron Pipe.
Youngstown Steel Pipe.
Valve and Service Boxes.

236 Congress St., Boston, Mass.
Telephone, Hancock 7817-7818



HOT METAL

is tested by pyrometer before being cast into parts for Darling Valves. The metal must be poured at exactly the right temperature to prevent blow holes and other casting imperfections. This test for critical temperature is one of many precautions employed by Darling for your protection.

. . . AND COLD FACTS

prove the value of this professional approach to valve manufacturing. Darling Valves give superior performance because they are made by artisans who take pride and care in their workmanship. Specify Darlings for your next valve installation!

DARLING VALVE & MANUFACTURING COMPANY

WILLIAMSPORT, PA.

Representatives in:

NEW YORK OKLAHOMA CITY HOUSTON PHILADELPHIA
PITTSBURGH TOLEDO EVANSTON, ILL.

DARLING
VALVES & FIRE HYDRANTS

TIGHT JOINTS

REGARDLESS OF PIPE SIZE OR SOIL CONDITION

UNDER all conditions of service cast iron water mains can be laid with assurance of permanently "bottle-tight" joints if HYDRO-TITE is used as the jointing compound.

No matter how large or small the pipe nor how tough the going may be, HYDRO-TITE will prove the easiest and most economical to use.

HYDRO-TITE has a record of more than a quarter century without a failure anywhere.

A Symbol of Quality

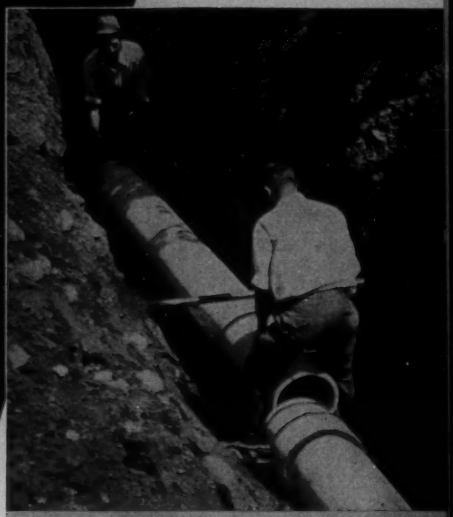
A Dependable Self-Caulking Joint Compound

HYDRO-TITE

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office: 50 Church Street, New York, N. Y.
General Offices and Works: West Medford Station, Boston, Mass.

CAN YOU USE THESE WATER-LINE SAVINGS?



COSTS GO DOWN right at installation when you use J-M Transite Pipe. Its long lengths, light weight and simple assembly get jobs finished in the shortest possible time. Savings continue in service, for Transite's asbestos-cement composition is highly resistant to corrosion. Tuberculation is impossible . . . pumping costs stay low.

IN HUNDREDS of American communities, J-M Transite Pipe is reducing water-transportation costs these three ways:

INSTALLATION is less expensive because Transite Pipe comes in long, light lengths . . . is easily transported and handled. Simplex Couplings make assembly simple and rapid . . . eliminate the need for skilled crews. Because large bell holes are unnecessary on any job, trenches are held to minimum widths.

MAINTENANCE stays low throughout the system's long life. Made of asbestos and cement, Transite is unusually resistant to the corrosive action of acid soils and ground water. Being 100% non-metallic, it is completely immune to electrolysis.

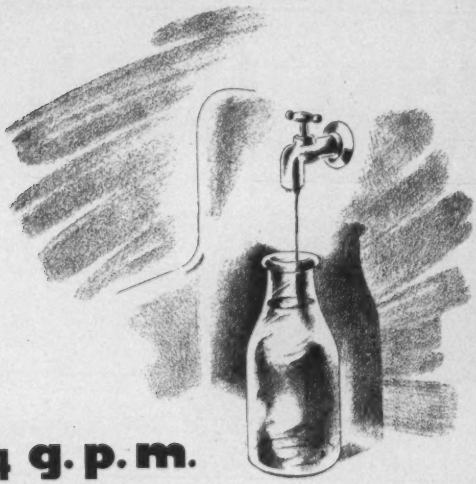
OPERATION is more economical right from the start. Transite's smooth interior surface has an unusually high flow coefficient (C=140). And since Transite contains no metal, it cannot tuberculate under any conditions. Pumping costs stay low.

* * *

Careful consideration of the facts on Transite Pipe will show you how this modern material provides better water service at lower cost. Brochure TR-11A gives full details. For your copy, write Johns-Manville, 22 East 40th Street, New York, N. Y.

Johns-Manville TRANSITE PIPE AN ASBESTOS PRODUCT

THE MODERN MATERIAL FOR WATER AND SEWER LINES



Only ¼ g.p.m.

but the EMPIRE METER records it with scarcely a spoonful lost

One-quarter gallon per minute is a pretty thin stream of water . . . yet the EMPIRE METER measures it with 98.3% accuracy.

Even on flows down to 1/12 g.p.m., and less, the EMPIRE keeps a profitable record of water used — or wasted. Profitable? Yes, indeed. Even at a rate as low as 15 cents per 1000 gallons, a 1/32-inch dribble of water is worth TEN DOLLARS PER YEAR.

That's why accuracy specifications are more exacting today than ever before. And note particularly that EMPIRE METERS have been meeting and even exceeding these present-day specifications FOR MORE THAN FIFTY YEARS.

The EMPIRE is the premier meter for accuracy as well as economy.

National Meter Company, 4209 First Avenue, Brooklyn, N. Y.
Branches in Boston, Chicago, Dallas, Los Angeles, San Francisco, Seattle

NATIONAL PERFORMANCE PROVED **METERS**

PLAN NOW TO ATTEND

Fifty-ninth Annual Convention

NEWWA

Hotel Commodore, New York City

September 24-27, 1940

Have you a *Safety First* CAMPAIGN in your community?

···*Kennedy* SAFETOPS *will help you*

SAFETOP means Safety First in fire hydrant design—safety to occupants of vehicles that may crash into the hydrants, safety from lengthy interruption to fire protection in case of breakage, and safety to the neighborhood in fire service.

If an automobile or truck should smash into a SAFETOP Hydrant, there is no likelihood of serious personal injuries, and no escape of water to block traffic or damage neighborhood property.

Instead, the patented Safety Breakable Section of the SAFETOP parts cleanly, and the hydrant can be returned to service within half an hour, without shutting off the water, and at a total cost of less than $10.00 for parts and labor.

In fire service, the simple, straight-line operating mechanism can always be depended upon to respond promptly, and the large standpipe and easy elbow and nozzle curves assure delivery of full main pressure into the hose.

For Safety First—and for safety at ALL times—you should insist on Kennedy SAFETOPS for your community.

Descriptive folder and prices on request.

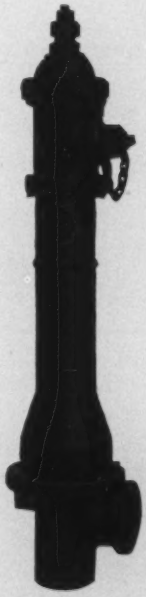
The Kennedy Valve Mfg. Co., Elmira, N. Y.

KENNEDY
SAFETOP FIRE HYDRANT

REG. U.S. PAT. OFF.

EDDY

Valves and Hydrants



Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

Eddy Valve Co.

WATERFORD NEW YORK

LEAD PIPE

Used by leading WATER WORKS for over 50 years. If proper weight is used, combined with good workmanship, your FINAL COST is assured, as REPAIRS are unnecessary. LEAD PIPE IS sufficiently ductile to conform to any sagging condition. There is no RUSTING of pipe or joints; no DISCOLORATION of water.

HIGHEST QUALITY SOFT OMAHA PIG LEAD

LEAD WOOL

Every atom pure lead

For calking pipe joints under the most difficult conditions.

RED LEAD

For rust-proofing tanks and pipes.

Write for Water Works specifications.

PURE BLOCK TIN PIPE **TIN-LINED LEAD PIPE**

DUTCH BOY WHITE LEAD

SOLDER

National-Boston Lead Co.

800 Albany Street **Boston, Mass.**

THE A. P. SMITH MFG. CO.,

East Orange, New Jersey

Makers of SMITH SPECIALTIES, such as tapping machines for making side connections to water mains under pressure, for inserting valves in existing straight line of pipe under pressure, for placing house service connections in mains under pressure and many other labor saving devices for use in water and gas department work.

See full description in Catalogue No. 39.

Also ask for Hydrant Booklet describing new "Protectop" Type.

SMITH

WATER WORKS SPECIALTIES & SUPPLIES

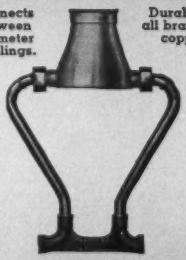
THE A.P.SMITH MFG. CO. *East Orange, N.J.*

The Ford Resetter

AN IDEAL FITTING *for* RAISING TOO-LOW METERS EASILY

Connects between old meter couplings.

Durable,—all brass and copper.



Improve your old meter settings by installing the RESETTER. Bring your water meters up out of the mud and water so that they are easier to read and take care of. Write for catalog.

The Ford Meter Box Co.

WABASH, INDIANA

THE BEST

Valve

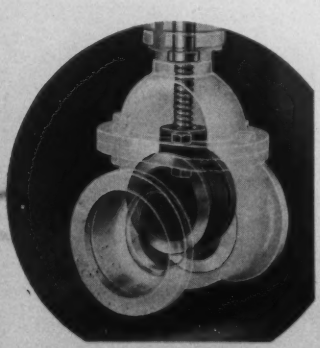
PROVIDES Smooth, Positive Operation

A valve must be so constructed as to allow smooth opening and closing with the least possible effort. To guarantee this effect, the best valve positions gates directly opposite ports before wedging, and entirely *unwedges* the gates before raising them.

The best valve also cleans itself, allows ready replacement of parts through ample tolerances, and guarantees positive closure with self-releasing 30° angle wedges, and flexible-action gates *self-adjusting* to seats.

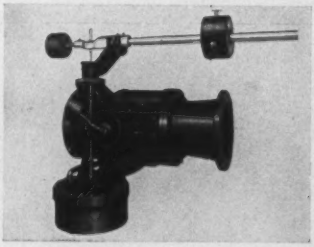
Only the parallel seat, double wedge type slide gate valve provides *all* these essential benefits. This principle, developed and perfected by Ludlow, has been the universally accepted construction in all *water works valves* for nearly three-quarters of a century.

Information free on request.



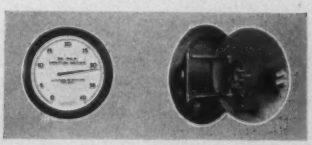
The LUDLOW VALVE MFG·CO·INC· SINCE 1866 TROY·N·Y·

BUILDERS *Improved Metering and Controlling Equipment*



Type E Direct Acting Controller

Features: precise control; compact, yet flexible design; powerful "floating piston" actuation with unique rubber piston seal; low loss of head; elbow or straight outlet; single blade vane-type valve; and others. *Bulletin 321*



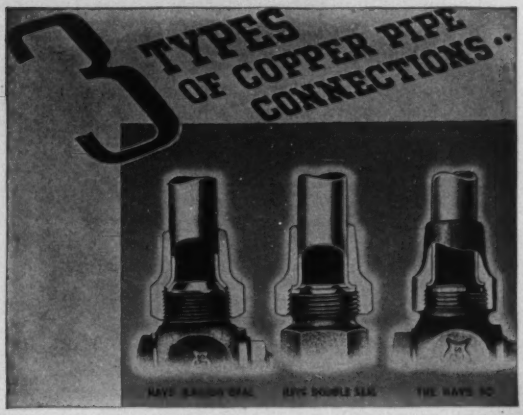
Chronoflo Large Dial Illuminated Indicator

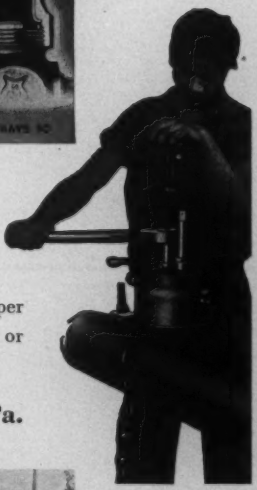
Useful and ornamental! Entire mechanism on sturdy, concealed, double hinges permits adjustments without removal of dial or working parts. *Bulletin 317*

Flo-Watch

Attractive in appearance, accurate over wide range, sturdily constructed. *Bulletin 318*

BUILDERS·PROVIDENCE
BUILDERS IRON FOUNDRY CODDING ST. PROVIDENCE R. I.





Whatever tapping method or type of corporation cock your city uses, Hays can take off with copper pipe to the curb or to the meter. Hundreds of water works departments have found Hays permanent copper services readily adaptable to their needs at little or no extra cost over short life methods.

HAYS MFG. COMPANY Erie, Pa.

SINCE 1869

HAYS

4000 YEARS

OF WATER PURIFICATION

In an old Sanskrit manuscript, containing a collection of medical lore, appears this advice: "It is good to keep water in copper vessels, to expose it to the sunlight, and filter it through charcoal." The document was written about 2,000 B.C.

These days, the modern purifier AQUA NUCHAR Activated Carbon, is many times more powerful than ordinary charcoal as a purifying agent, and it is used by more than 1,100 cities throughout the United States to remove unpalatable tastes and odors in raw water supplies.

The cost of furnishing palatable drinking water through the use of AQUA NUCHAR Activated Carbon is so negligible that every purification plant should consider its continuous use throughout the entire year.

INDUSTRIAL CHEMICAL SALES

Division West Virginia Pulp & Paper Company

230 PARK AVENUE **NEW YORK CITY**

Manufacturers of AQUA NUCHAR AQUA ***Activated Carbon***

DE LAVAL

MIXED FLOW PUMPS FOR FLOOD CONTROL

North Meadows Pumping Station, Hartford, Conn.

While this is not a Water Works Plant, it illustrates a type of pump for large capacities against low heads, suitable for raw water service.

The photograph shows three 36″ vertical pumps which are driven through right angle spiral bevel gears by horizontal gasoline engines. The pump in the foreground is a 16″ vertical unit driven by a vertical electric motor. The capacity of each 36″ pump is 35,000 g.p.m. against 20 ft. head. The capacity of the 16″ pump is 5,000 g.p.m. against 13 ft. head.

This project was engineered by U. S. Engineers' Office, Providence, R. I.

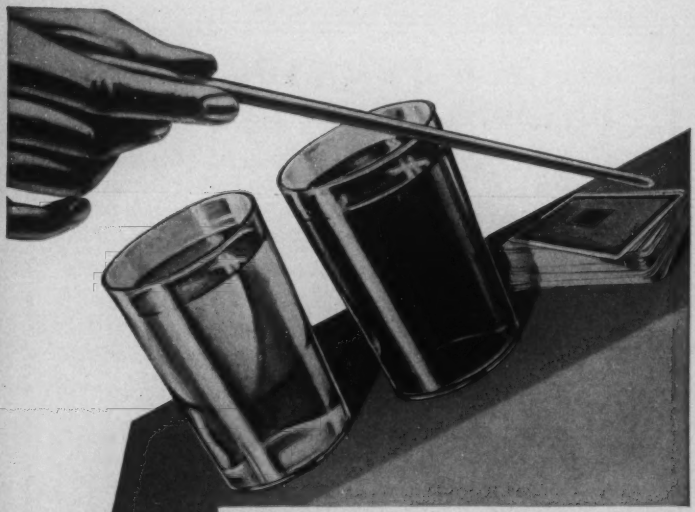
TURBINE EQUIPMENT COMPANY OF NEW ENGLAND

80 Federal Street **Phone LIBerty 5993-5994** **Boston, Mass.**

New England Representatives for

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY



PRESTO CHANGE-O

Tastes and Odors disappear from drinking water as if by magic with

BREAK-POINT CHLORINATION BY W&T

MAGICAL — YES! MYSTIFYING — NO! — not if once you read "Taste and Odor Control with BREAK-POINT CHLORINATION"—W&T Technical publication 207,—a copy of which is yours for the asking. Better yet—your nearest W&T representative can make tests AT YOUR PLANT and tell immediately if BREAK-POINT CHLORINATION is likely to solve your problem. Why not 'phone him now?

BREAK-POINT CHLORINATION by W&T

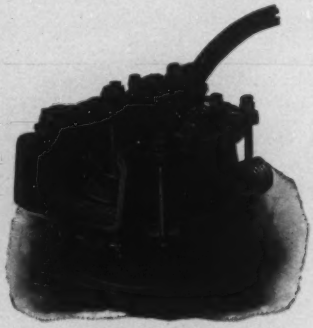
"The Only Safe Water Is a Sterilized Water"

WALLACE & TIERNAN CO. Inc.

Manufacturers of Chlorine and Ammonia Control Apparatus

NEWARK, NEW JERSEY BRANCHES IN PRINCIPAL CITIES

EDSON
PUMPS and ACCESSORIES



Hand Pumps – Power Pumps
Truck or Trailer Mounted
Edson Special Suction Hose
Red Seal Diaphragms
Edson Bronze Hydrant Pump
Strainers, Adapters, etc.

Distributors for
Pollard Pipe Line Equipment
Redi-Prime Pumps
Electric Pipe Thawers

Universal Water Leak Detector

THE EDSON CORPORATION
49 D Street, Tel. SOUth Boston 3041 South Boston
New York: 142 Ashland Place, Brooklyn

Warren Foundry & Pipe Corp.
ALSO
Warren Pipe Co. of Mass., Inc.

SALES OFFICES
11 BROADWAY, NEW YORK
75 FEDERAL STREET, BOSTON, MASS.

Manufacturers of

CAST IRON PIPE

Flanged Pipe ***Flexible Joint Pipe***
Bell and Spigot Pipe
Special Castings ***Short Body B. & S. Specials***
Warren (WF) Spun Centrifugally Cast Iron Pipe

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments

Few Products In Any Field Are So Clearly Recognized for Superiority of Service As

SPUN **BITUMASTIC** LINING

REG. U.S. PAT. OFF.

The Report of the Committee on PIPE LINE COEFFICIENTS of the New England Water Works Association definitely proves the absolute economic necessity of lining all water pipe.

BITUMASTIC SPUN LINING is assigned a higher value of the coefficient *C* than any other lining. This insures the highest initial flow. More important —this high flow will be maintained for many years.

BITUMASTIC ENAMEL is not affected by tuberculating waters. Actual inspection of pipe in service and carrying tuberculating waters shows BITUMASTIC unaffected. This is real proof.

No taste, color, or odor imparted to the water.

Write for further information.

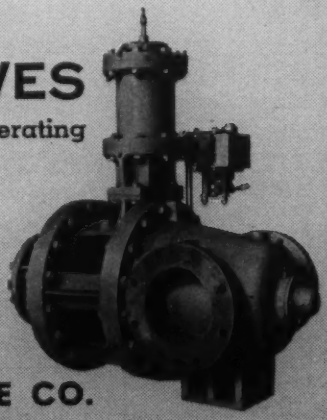
Wailes Dove-Hermiston Corporation

17 Battery Place, New York, N. Y.

Rensselaer
CONE VALVES
(Patented Hydraulic Operating Device)

Used for

- **ALTITUDE CONTROL**
- **PRESSURE RELIEF**
- **PRESSURE REDUCING**
- **AUTOMATIC CHECK**



RENSSELAER VALVE CO.
TROY, NEW YORK

Let's look at the Record!

NEW ENGLAND MUNICIPALITIES PREFER F-M PUMPS FOR ECONOMICAL WATER SUPPLY

Wide-awake municipalities throughout New England have shown their preference for Fairbanks-Morse pumping equipment. New names are constantly being added to the long list of New England Municipal pumping stations—names that voice enthusiastic preference for "Fairbanks-Morse." Almost without exception, the many municipalities that have specified Fairbanks-Morse pumping equipment are showing substantial savings in operating and maintenance costs. These municipalities offer evidence which once again bespeaks the high efficiency of all Fairbanks-Morse products.

Here Are a Few N. E. Municipalities Now Using F-M Pumps

LOCATION	ENGINEER
Reading Water Works	Weston & Sampson, Engineers
Needham Water Works	Bayard F. Snow, Engineer
Lawrence Water Works	Metcalf & Eddy, Engineers
Wareham Water Works	Fay Spofford & Thorndike, Engineers
Quincy Water Works	Whitman & Howard, Engineers
Amherst Sewage Works	F. A. Barbour, Engineer

FAIRBANKS MORSE

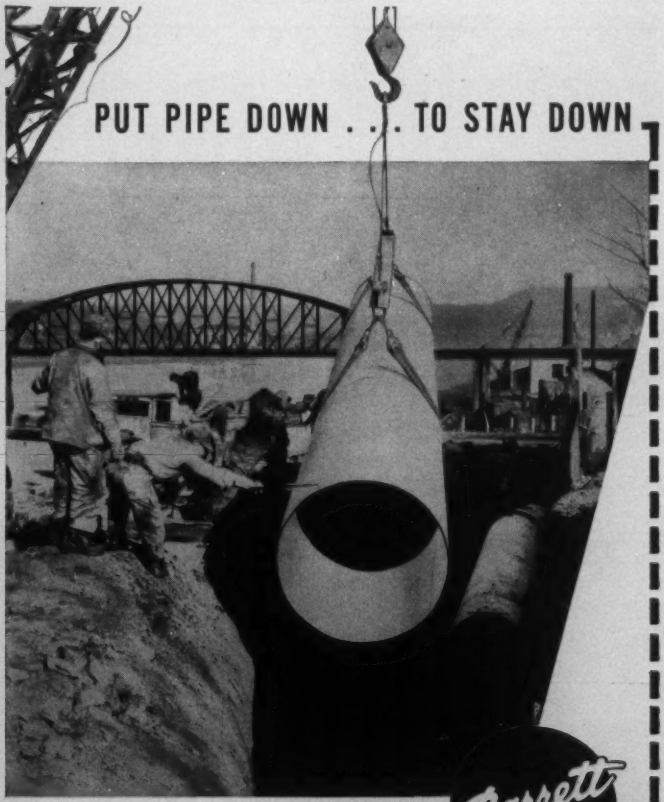
DIESEL ENGINES · PUMPS · ELECTRICAL MACHINERY · FAIRBANKS SCALES · RAILROAD EQUIPMENT · WATER SYSTEMS · WASHERS-IRONERS · FARM EQUIPMENT · STOKERS · AIR CONDITIONERS

F M

Pumps

Vol. 5
194

PUT PIPE DOWN . . . TO STAY DOWN



Barrett Enamel—Water Department, Pittsburgh, Pa.
Bethlehem Steel Corporation, fabricators.

RUINOUS external stresses resulting from moisture, soil, acids and stray electric currents—and injurious internal corrosion as well — are thwarted by Barrett Waterworks Enamel. These durable protective coatings, produced from the most stable bituminous substance known for underground pipe protection, are practically impervious to water absorption, are highly dielectric, and are resistant to mechanical distortion.

Lasting protection at low initial cost is further assured by the uniform quality of Barrett Enamels and careful Barrett supervision of the coating job. To keep pipe down to stay, specify Barrett.

Barrett
WATERWORKS
ENAMEL

FIELD SERVICE To help engineers achieve top-notch efficiency in their use of Barrett Waterworks Enamels, we offer the resources of our Waterworks Service Department and Field Service staff. We will appreciate your inquiries.

THE BARRETT COMPANY, 40 RECTOR STREET, NEW YORK, N. Y.

MORRIS Centrifugal Pumps

for Sewage and other services

in New England's large cities and small towns

More than 36 New England communities have set their seal of approval on Morris Centrifugal Pumps, ranging in size from the largest municipalities . . . Boston, Providence, Worcester . . . to small towns of 1500 population and even less.

Your community, too, should have the assurance of uninterrupted, economical and trouble-free operation provided by Morris Pumps on water supply, sewerage, storm water drainage, and general plant services.

Bulletins on request

STARKWEATHER ENGINEERING COMPANY, Inc.
NEWTON, MASSACHUSETTS
New England Representative

MORRIS CENTRIFUGAL PUMPS

for every municipal service

HOW MILFORD, N. H., CURVED *"Century"* ASBESTOS-CEMENT PIPE WITHOUT USING ELBOWS OR BENDS

Right-of-way trouble at the last minute forced Milford, N. H., to change its plans for a pipe line from a straight line to a 90° curve of 50' radius. The material was already at the site—straight lengths of 12" "Century" Asbestos-Cement Pipe—and everything was ready for laying.

IN a 12" line recently laid, the town of Milford, N. H., used 5200 feet of "Century" Asbestos-Cement Pipe, selecting it because of its many advantages. As illustrated, the use of "Century" Pipe also helped to solve an unusual and utterly unexpected problem.

"Century" Asbestos-Cement Pipe, made of two of the most enduring materials known—asbestos and cement—insures lasting relief from such costly pipe diseases as tuberculation and corrosion. It is light, but strong. With it, you use "Century" Flexible Couplings which are really *flexible*, easy to install, and permanently leak-proof.

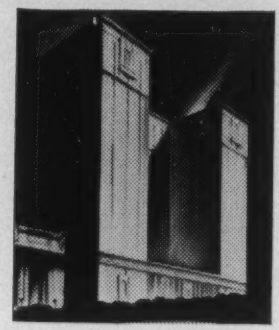
Write Keasbey & Mattison, asbestos specialists since 1873, for free illustrated catalogue, "Mains without Maintenance." Address Department 1017.

Right in the field the standard lengths were quickly and easily sawed into three sections each, and coupled with "Century" Flexible Couplings to form the needed short-radius curve. The finished job is ready for generations of leak-proof, trouble-free service.

Mr. R. F. Campbell, Superintendent of the Milford, N. H., Water Works, who says: "We chose 'Century' Asbestos-Cement Pipe because of its low first cost and its all-around economy due to low laying and low maintenance cost."

KEASBEY & MATTISON
COMPANY, AMBLER, PENNSYLVANIA

FAMOUS FOR FUNCTIONS



Headquarters for the Convention of the New England Waterworks Association September 23rd to 27th and the choice of leading organizations all over America for conferences, conventions and functions, the Commodore is a truly famous host . . . Assembly and banquet rooms accommodating 35 to 3500 persons . . . Four roomy restaurants . . . expert service.

2000

large, comfortable guest rooms,
all with private bath — from $3

THE Commodore

"New York's Best Located Hotel"

MARTIN SWEENY, President

RIGHT AT GRAND CENTRAL TERMINAL

***MIXED* Right - *STAYS* Right**

Certain chemical compounds may suffer in journeying from here to there. Jouncing and jolting of truck or freight car may cause the "heavies" of some jointing compounds to seek the bottom of the sack - But the Tegul-MINERALEAD **ingot** can jump and jive like a jitterbug without upsetting its correct balance or impairing its efficiency - This ingot form has still **further** advantages; it's impervious to rain and flood, and is easily handled, stored and shipped - Tegul-MINERALEAD needs no skilled labor, no caulking, no deep bell holes - Makes permanently tight joints, well able to withstand far more vibration than they're ever likely to meet in service - To make the closer acquaintance of this Jointing Compound with Advantages, write the ATLAS MINERAL PRODUCTS Company of Penna., Mertztown, Pennsylvania.

Tegul- MINERALEAD

DONALDSON IRON CO.

MANUFACTURERS

. . . OF . . .

CAST IRON PIPE

. . . AND . . .

Special Castings for Water and Gas

Also Flange Pipe and Fittings

EMMAUS, LEHIGH COUNTY, PA.

New York Office: E. A. NOONAN, 225 Broadway

This Mathews is the only hydrant I know with a "3-way ground line." You can *raise* the grade level without moving the hydrant at its elbow by screwing a longer barrel into its protection case. You can *lower* it by cutting down the loose protection case and using a shorter barrel. Or the "ground line" is free to heave up with frozen ground and yet put no strain on water-carrying parts.
But look: The real advantage of a threaded barrel inside a loose protection case is that you can always repair, inspect or overhaul any working part without digging. I say, "Standardize on Mathews Hydrants."

The outer protection case acts as a loose sleeve through which all working parts can be unscrewed and lifted out, repaired, or replaced. Write for prices on Mathews Hydrants and interchangeable barrels.

MATHEWS HYDRANTS

Made by R. D. WOOD COMPANY

Manufacturers of Sand Spun Pipe (centrifugally cast in sand molds) and R. D. Wood heavy-duty gate valves for water works

400 CHESTNUT STREET, PHILADELPHIA, PA.

CLASSIFIED DIRECTORY OF ADVERTISEMENTS

Page

ACTIVATED CARBON.
Industrial Chemical Sales Division—West Virginia Pulp and Paper Co. xix

AIR CONDITIONING EQUIPMENT.
Worthington Pump and Machinery Corp. vii

AIR COMPRESSORS.
Worthington Pump and Machinery Corp. vii

ASBESTOS CEMENT PIPE.
Johns-Manville xi
Keasbey & Mattison Co. xxvii

BRASS GOODS.
(See also Pipe, Brass.)
Caldwell, George A., Co. xxxvii
Cement Lined Pipe Co. viii
Hays Mfg. Co. xviii
Mueller Co. xxxv
Pierce-Perry Co. viii
Red Hed Mfg. Co. xxxvi
Smith Mfg. Co., The A. P. xvi

CALKING MACHINERY AND TOOLS.
Mueller Co. xxxv
Smith Mfg. Co., The A. P. xvi

CAST IRON PIPE. (See Pipe, Cast Iron.)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHECK VALVES.
Darling Valve & Mfg. Co. ix
Mueller Co. xxxv

CHEMICAL FEED APPARATUS.
Builders Iron Foundry xvii
Wallace and Tiernan Co., Inc. xxi

CHLORINATORS.
Builders Iron Foundry xvii
Wallace and Tiernan Co., Inc. xxi

CLAMPS, RIVER.
Dresser Mfg. Co. Following front cover

CLAMPS, SERVICE.
Mueller Co. xxxv

CLEANING WATER MAINS.
National Water Main Cleaning Co. viii

COCKS, CURB AND CORPORATION.
Caldwell, George A., Co. xxxvii
Hays Mfg. Co. xviii
Mueller Co. xxxv
Pierce-Perry Co. viii
Red Hed Mfg. Co. xxxvi
Smith Mfg. Co., The A. P. xvi

CONCRETE PIPE. (See Pipe, Concrete.)

CONDENSERS.
Worthington Pump and Machinery Corp. vii

CONTRACTORS' EQUIPMENT.
Morris Machine Works xxvi
Worthington Pump and Machinery Corp. vii

CONSTRUCTION EQUIPMENT.
Edson Corp., The xxii

CONSTRUCTION AIR TOOLS.
Worthington Pump and Machinery Corp. vii

CONTRACTORS.
National Water Main Cleaning Co. viii
Reppucci, C. & Sons, Inc. iii

COUPLINGS, FLEXIBLE PIPE.
Dresser Mfg. Co. Following front cover

COUPLNGS, REPAIR.
Caldwell, George A., Co. xxxvii

CURB BOXES.
Bingham and Taylor iv
Caldwell, George A., Co. xxxvii
Hays Mfg. Co. xviii
Mueller Co. xxxv

CURB AND VALVE BOX FINDERS.
Caldwell, George A., Co. xxxvii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

	Page
DIAPHRAGMS, PUMP.	
Edson Corp., The	xxii
ENGINEERS.	
Bailey, Howard E.	iii
Barbour, Frank A.	ii
Barrows, H. K.	ii
Crosby, Irving B.	iii
Ellsworth, Samuel M.	ii
Fay, Spofford & Thorndike	ii
Goodnough, Inc., X. Henry	ii
Knowles, Morris, Inc.	ii
Metcalf & Eddy	ii
Newsom, Reeves	ii
Pirnie, Malcolm	ii
Pitometer Co.	ii
Potts, Clyde	iii
Weston & Sampson	iii
Whitman & Howard	iii
ENGINES. (See Pumps and Pumping Engines.)	
EQUIPMENT. (See Contractors' Equipment.)	
ERECTORS, WATER WORKS AND POWER MACHINERY.	
Turbine Equipment Co.	xx
FEED WATER HEATERS.	
Ross Valve Mfg. Co.	viii
Worthington Pump and Machinery Corp.	vii
FILTER RATE CONTROLLERS AND GAGES. (See Rate Controllers.)	
Ross Valve Mfg. Co.	viii
FILTRATION PLANT EQUIPMENT.	
Builders Iron Foundry	xvii
Morris Machine Works	xxvi
Ross Valve Mfg. Co.	viii
Wallace & Tiernan Co., Inc.	xxi
FLEXIBLE JOINTS.	
U. S. Pipe and Foundry Co	Facing back cover
FLAP VALVES.	
Mueller Co.	xxxv
FURNACES, ETC.	
Atlas Mineral Products Co.	xxix
Leadite Co., The	Back cover
Mueller Co.	xxxv
Smith Mfg. Co., The A. P.	xvi
GATE VALVES. (See Valves.)	
GUNITE.	
National Gunite Contracting Co.	iii
HOSE, SUCTION AND CONDUCTION.	
Edson Corp., The	xxii
HYDRANTS, FIRE.	
Darling Valve & Mfg. Co.	ix
Eddy Valve Co.	xv
Kennedy Valve Mfg. Co.	xiv
Ludlow Valve Mfg. Co.	xvii
Mueller Co.	xxxv
Rensselaer Valve Co.	xxiii
Ross Valve Mfg. Co.	viii
Smith Mfg. Co., The A. P.	xvi
Wood, R. D., Co.	xxx
HYDRANT PUMPS.	
Edson Corp., The	xxii
INSTRUMENTS. (See Water Works Instruments.)	
LEAD.	
National-Boston Lead Co.	xvi
LEAD PIPE. (See Pipe, Lead.)	
LEAD WOOL.	
National-Boston Lead Co.	xvi
LEAK FINDERS.	
Pitometer Co.	ii
Edson Corp., The	xxii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

	Page
METERS, WATER AND OIL.	
Builders Iron Foundry	xvii
Hersey Mfg. Co.	v
National Meter Co.	xii
Neptune Meter Co.	vi
Pitometer Co.	ii
Pittsburgh Equitable Meter Co.	Following front cover
Worthington Pump and Machinery Corp.	vii
METER COUPLINGS.	
Ford Meter Box Co.	xvi
METERS (VENTURI TYPE).	
Builders Iron Foundry	xvii
Mueller Co.	xxxv
National Meter Co.	xii
METER BOXES.	
Bingham and Taylor	iv
Ford Meter Box Co.	xvi
METER TESTERS.	
Ford Meter Box Co.	xvi
Mueller Co.	xxxv
OIL ENGINES, DIESEL.	
Fairbanks-Morse Co.	xxiv
Worthington Pump and Machinery Corp.	vii
PACKING.	
H. D. Jackson	iii
PAINTING.	
Tredennick, J. H., Inc.	Preceding index of advertisers
PIPE, BRASS.	
Caldwell, George A., Co.	xxxvii
Pierce-Perry Co.	viii
PIPE, CAST IRON (AND FITTINGS).	
Builders Iron Foundry	xvii
Donaldson Iron Co.	xxix
U. S. Cast Iron Pipe and Foundry Co.	Facing back cover
Warren Foundry and Pipe Corp.	xxii
Wood, R. D., Co.	xxx
PIPE, CEMENT LINED.	
Cement Line Pipe Co.	viii
Eureka Pipe Co., Inc.	iii
PIPE, CENTURY.	
Keasbey & Mattison Co.	xxvii
PIPE, CONCRETE.	
Lock Joint Pipe Co.	Facing front cover
PIPE CUTTING MACHINES.	
Smith Mfg. Co., The A. P.	xvi
PIPE JOINTING MATERIAL.	
Atlas Mineral Products Co.	xxix
Hydraulic Development Co.	x
Leadite Co., The	Back cover
PIPE, LEAD.	
National-Boston Lead Co.	xvi
PIPE LINING.	
Wailes Dove-Hermiston	xxiii
PIPE, TRANSITE.	
Johns-Manville	xi
PIPE, WROUGHT IRON AND STEEL.	
Pierce-Perry Co.	viii
PLUG VALVES.	
Mueller Co.	xxxv
PITOMETERS.	
Pitometer Co.	ii
PORTABLE AIR COMPRESSORS. (See Air Compressors.)	
POWER WIRE BRUSH, INC.	
Tredennick, J. H., Inc.	Preceding index of advertisers
PRESSURE REGULATORS.	
Caldwell, George A., Co.	xxxvii
Mueller Co.	xxxv
Ross Valve Mfg. Co.	viii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

	Page
PROVERS, WATER.	
Pittsburgh Equitable Meter Co.	Following front cover
PUMPS AND PUMPING ENGINES.	
Edson Corp., The	xxii
Fairbanks-Morse & Co.	xxiv
Morris Machine Works	xxvi
Ross Valve Mfg. Co.	viii
Turbine Equipment Co.	xx
Wood, R. D., Co.	xxx
Worthington Pump and Machinery Corp.	vii
RATE CONTROLLERS, AND GAUGES.	
Builders Iron Foundry	xvii
SHEAR GATES.	
Mueller Co.	xxxv
SLEEVES, PIPE LINE REPAIR.	
Dresser Mfg. Co.	Following front cover
SLEEVES, RIVER.	
Dresser Mfg. Co.	Following front cover
SLEEVES AND VALVES, TAPPING.	
Ludlow Valve Mfg. Co.	xvii
Mueller Co.	xxxv
Rensselaer Valve Co.	xxiii
Smith Mfg. Co., The A. P.	xvi
SLUICE GATES.	
Mueller Co.	xxxv
STANDPIPES.	
Tredennick, J. H., Inc.	Preceding index of advertisers
SUPPLIES AND TOOLS.	
Caldwell, George A., Co.	xxxvii
Hays Mfg. Co.	xviii
Leadite Co., The	Back cover
Pierce-Perry Co.	viii
Smith Mfg. Co., The A. P.	xvi
TAPPING MACHINES.	
Hays Mfg. Co.	xviii
Mueller Co.	xxxv
Red Hed Mfg. Co.	xxxvi
Smith Mfg. Co., The A. P.	xvi
TAPPING SLEEVES. (See Sleeves and Valves, Tapping.)	
VALVE BOXES.	
Bingham and Taylor	iv
Caldwell, George A., Co.	xxxvii
Ford Meter Box Co.	xvi
Mueller Co.	xxxv
Rensselaer Valve Co.	xxiii
Wood, R. D., Co.	xxx
VALVE INSERTING MACHINES.	
Smith Mfg. Co., The A. P.	xvi
VALVES, GATE.	
Darling Valve & Mfg. Co.	ix
Eddy Valve Co.	xv
Kennedy Valve Mfg. Co.	xiv
Mueller Co.	xxxv
Rensselaer Valve Co.	xxiii
Ross Valve Mfg. Co.	viii
Smith Mfg. Co., The A. P.	xvi
Wood, R. D., Co.	xxx
VALVES, REGULATING.	
Mueller Co.	xxxv
Ross Valve Mfg. Co.	viii
WATER WASTE DETECTION.	
Pitometer Co.	ii
WATER WORKS INSTRUMENTS.	
Caldwell, George A., Co.	xxxvii
WATER WORKS JOURNALS.	
Journal of the New England Water Works Association	ii
WELL CONNECTIONS.	
Red Hed Mfg. Co.	xxxvi
WROUGHT IRON PIPE. (See Pipe, Wrought Iron and Steel.)	

4-POINT CONTACT

EQUAL PRESSURE AT THE EDGES

EQUAL PRESSURE AT THE EDGES

EQUAL PRESSURE AT THE EDGES

EQUAL PRESSURE AT THE EDGES

Mueller-Columbian parallel seat, double disc Gate Valves use the FOUR-POINT principle of applying wedging action against the valve discs. The force is applied equally at four points near the edges of each disc which reduces the mechanical strain and deflection of the discs.

This is an exclusive feature found only in Mueller-Columbian Gate Valves and is one very good reason why they have a reputation among water works men for dependable service and low maintenance cost.

MUELLER CO.

CHATTANOOGA, TENN.

RED HED ADAPTERS

FOR

COPPER SERVICE TUBE

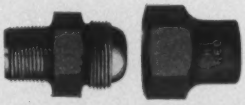


Fig. 402
Copper to Iron Coupling Male

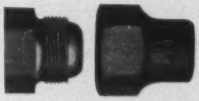


Fig 413
Copper to Iron Coupling Female

Fig. 412
Copper to Copper Coupling. Three Piece.

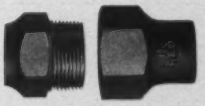


Fig. 411
Copper to Copper Coupling with Ring

Fig. 423
Corporation to Copper Tube

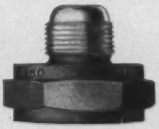


Fig. 450
Lead Flange to Copper Adapter

Fig. 425
90° Ell Copper to Iron Female

All RED HED Adapters are made of 85% Copper Bronze, Heavy Pattern Full Length Accurate Threads.

You will have no trouble making good tight joints with RED HED Adapters.

RED HED MFG. CO.

Makers of RED HED Brass Goods For Waterworks

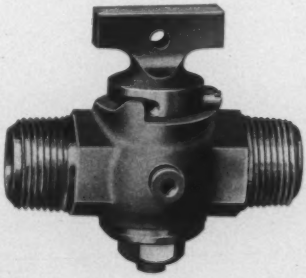
368 CONGRESS ST.

BOSTON **MASS.**

GROWING!

While meeting your present requirements,
To meet your future requirements,
On SERVICE, QUALITY, and DEPENDABILITY,
With our loyal older customers and the many new ones

That's the story of our BRASS GOODS LINE. Growing larger in sales, longer in line and steadfast in quality



We appreciate the loyalty of our New England customers and in return, do strive constantly to show our gratitude, by improving our service as we can from time to time to make your purchases more profitable to you.

Our representatives thank you personally as they meet you, and we herewith publicly thank you all again for your courtesies.

GEORGE A. CALDWELL COMPANY

Everything For Water Service Work from Main to Meter

Phone BLUe Hills 2791

BOSTON **Mattapan Square** **MASSACHUSETTS**

CAST IRON pressure pipe for underground service has a useful life of one hundred years. This is virtually an engineering axiom applying to *all* cast iron pressure pipe since all of it is made to specifications. But specification products can have plus-values, as in the case of Super-de Lavaud *chill-free* centrifugally cast pipe. This pipe, made by a special process, combines extraordinary impact-resistance with great strength and ductility.

U.S. cast iron PIPE

Centrifugally or Pit Cast for water works, gas, sewerage, drainage and industrial services.

U. S. PIPE & FOUNDRY CO.
General Offices, Burlington, N. J.
Plants and Sales Offices throughout the U. S. A.

The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with reports of the discussions. Many of the contributions are from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between the members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness.

All members of the Association receive the JOURNAL for two dollars per annum which sum is included in their annual dues; to all others the subscription is four dollars per annum.

TO ADVERTISERS

THE attention of parties dealing in goods used by Water Departments is called the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION as an advertising medium.

Its subscribers include the principal WATER WORKS ENGINEERS and CONTRACTORS in the United States. The paid circulation is **1000** COPIES.

Being filled with original matter of the greatest interest to Water Works officials it is PRESERVED and constantly REFERRED TO BY THEM, and advertisers are thus more certain to REACH BUYERS than by any other means.

The JOURNAL is not published as a means of revenue, advertisements being inserted solely to help meet the large expense of publication.

ADVERTISING RATES

One page, one year, four insertions	Eighty Dollars
One-half page, one year, four insertions	Fifty-six Dollars
One-fourth page, one year, four insertions	Thirty-six Dollars
One-twelfth page (card), one year, four insertions	Twelve Dollars
One page, single insertion	Forty Dollars
One-half page, single insertion	Thirty Dollars
One-fourth page, single insertion	Twenty Dollars

Size of page, 4½ x 7½ net.

A sample copy will be sent on application.

For further information, address the Advertising Agent,

(Miss) MARCELLA SACHS,
613 STATLER BUILDING,
BOSTON, MASS.

LEADITE

— is known wherever Water Mains are laid

In Large Cities,—in Small Towns,—in Water Systems of Industrial Plants, Railroads and Mines,—Leadite has been successfully used for jointing Bell and Spigot Water Mains from 4-in. to 84-in. diameter (inclusive),—and for various pressures. In fact, many thousands of miles of water mains in the United States and its Possessions; Latin America, and numerous Overseas Countries, have been satisfactorily jointed with LEADITE.

If you are not already using LEADITE, we feel that it would be worth your while to investigate it,—and try it on your next pipe laying job.

The Pioneer self-caulking material for c. i. pipe.
Tested and used for over 35 years.
Saves at least 75%

THE LEADITE COMPANY

Girard Trust Company Building — Philadelphia, Penna.